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REPORT FOR BENCH-SCALE SOIL/SEDIMENT TREATABILITY STUDY AT SITE 8 HERBICIDE ORANGE STUDY AREA NCBC GULFPORT MS

3/1/2001

TETRA TECH

Report
Bench-Scale Soil/Sediment Treatability Study

Site 8
Herbicide Orange Study Area

at

Naval Construction Battalion Center

Gulfport, Mississippi

Southern Division
Naval Facilities Engineering Command

Contract Number N62467-94-D-0888

Contract Task Order 0143

March 2001

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REPORT
FOR
BENCH-SCALE SOIL/SEDIMENT TREATABILITY STUDY

SITE 8
HERBICIDE ORANGE STUDY AREA

NAVAL CONSTRUCTION BATTALION CENTER
GULFPORT, MISSISSIPPI

COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT

Submitted to:
Southern Division
Naval Facilities Engineering Command
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North Charleston, South Carolina 29406

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CONTRACT NUMBER N62467-94-D-0888
CONTRACT TASK ORDER 0143

MARCH 2001

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LIST OF ACRONYMS AND ABBREVIATIONS

AASHO	American Association of State Highway Officials
ABB-ES	ABB Environmental Services
ASTM	American Society for Testing and Materials
CBR	California Bearing Ratio
CKD	cement kiln dust
CLEAN	Comprehensive Long-Term Environmental Action Navy
CTO	Contract Task Order
DOT	U.S. Department of Transportation
HLA	Harding Lawson Associates, Inc.
HO	Herbicide Orange
H20	Highway 20
MSDEQ	Mississippi Department of Environmental Quality
µg/kg	microgram per kilogram
NCBC	Naval Construction Battalion Center
ng/kg	nanogram per kilogram
SOUTHDIVNAVFACENGCOM	Southern Division Naval Facility Engineering Command
SRT	sediment recovery trap
TCDD	2,3,7,8-tetrachlorodibenzo-p-dioxin
TtNUS	Tetra Tech NUS, Inc.
USAF	U.S. Air Force

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1.0 INTRODUCTION

1.1 SCOPE AND PURPOSE

This Bench-Scale Treatability Study Report for Naval Construction Battalion Center (NCBC) Gulfport, Site 8, Herbicide Orange Study Area (Site 8) has been prepared by Tetra Tech NUS, Inc. (TtNUS) for the Southern Division Naval Facilities Engineering Command (SOUTHDIVNAVFACENGCOM) under the Navy Comprehensive Long-Term Environmental Action Navy (CLEAN) Program, Contract Number N62467-94-D-0888, Contract Task Order (CTO) 0143. This treatability study was conducted in accordance with the Work Plan, Bench-Scale Soil/Sediment Treatability Study, Site 8, Herbicide Orange Study Area (TtNUS, 2000a).

The purpose of this report is to describe the various testing activities of the soil ash and sediment stabilization bench-scale treatability study, present the results of these activities, and provide the conclusions and recommendations drawn from these results.

1.2 SITE HISTORY AND PROJECT BACKGROUND

Site 8 occupies approximately 30 acres in the north central section of NCBC Gulfport. From 1968 to 1977, the site was used by the U.S. Air Force (USAF) for the storage of approximately 850,000 gallons of Herbicide Orange (HO) in 55-gallon drums. It was originally believed that only 12 acres of the site, designated as Site 8A, had been used for HO storage, but two additional storage areas were later identified, including 17-acre Site 8B and 1-acre Site 8C. Figure 1-1 shows the location of Sites 8A, 8B, and 8C [ABB Environmental Services (ABB-ES), 1998].

The main chemical of concern at the site is 2,3,7,8-tetrachlorodibenzo-p-dioxin, or TCDD, which is a manufacturing impurity of the HO. In this document, TCDD and the other dioxins found in HO will be collectively referred to as "dioxin."

In 1977, the USAF disposed of the entire HO inventory by high-temperature incineration at sea. From 1987 to 1988, a quantity of dioxin-contaminated soil was treated on-site by high-temperature incineration and the resulting ash were stored on Site 8A. This ash meets the dioxin delisting concentration criterion of 1.0 microgram per kilogram (μg/kg) set by the Mississippi Department of Environmental Quality (MSDEQ, 1997).

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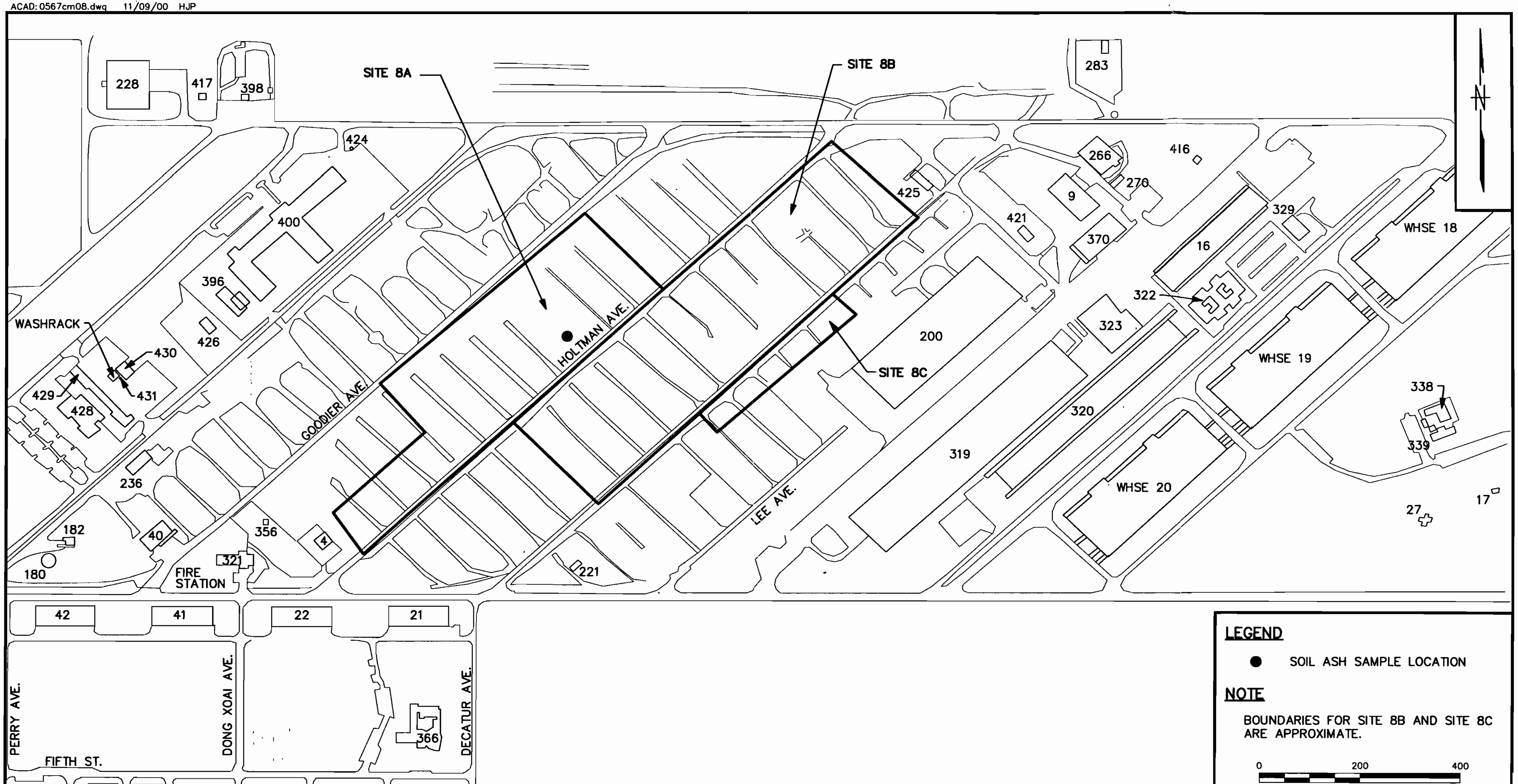

SOURCE: REMEDIATION GUIDANCE DOCUMENT, HARDING LAWSON ASSOCIATES, MARCH 2000.

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DEPARTMENT OF THE NAVY — SOUTHERN DIV FACILITIES ENGINEERING COMMAND

SITES 8A, 8B, AND 8C LOCATION MAP AND SOIL ASH SAMPLING LOCATION NAVAL CONSTRUCTION BATTALION CENTER GULFPORT, MISSISSIPPI

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As a result of the spills and leaks that occurred during the years of HO storage, dioxin has migrated from Site 8 to the system of on-base ditches which drains surface runoff from the site and to the off-base swampland located across 28th Street from Outfall 3. Since dioxin has an affinity for soil and is not readily water soluble, this migration has primarily occurred through the erosion and transportation of contaminated soil from the site and the deposition of this soil in the sediment of the on-base ditches and off-base swampland.

Site 8 is also currently used to store construction debris and dioxin-contaminated sediment excavated from ditches as part of removal actions conducted during the widening of 28th Street in 1995 and the 1997 upgrading of the sediment recovery trap (SRT) system located in the on-base drainage ditches.

The currently proposed remedial approach for the contaminated soil and sediment is to excavate dioxin-contaminated sediment from on-base drainage ditches and off-base swampland and to consolidate the excavated material on Site 8A with the incinerated soil ash and construction debris. The consolidated material would then be stabilized, capped and the capped area used as a parking and storage area.

1.3 VOLUMES OF CONTAMINATED MEDIA

Based upon an agreed-upon soil/sediment remedial goal of 50 nanograms per kilogram (ng/kg) dioxin, computations performed as part of this treatability study estimated that a total of approximately 58,600 cubic yards (yd^3) of contaminated media will have to be excavated and consolidated at Site 8A, including the following:

Material	Estimated Volume (yd^3)
Site 8A Incinerated Soil Ash	21,000(1)
Site 8A Construction Debris	600(1)
On-Base Ditches Contaminated Sediment	24,000(2)
Off-Base Swampland Contaminated Sediment	13,000(2)
Total	**58,600**

(1) Based upon the Remediation Planning Document [Harding Lawson Associates, Inc. (HLA), 2000]

(2) Based upon the Remediation Planning Document (HLA, 2000) and TtNUS Field observations and measurements.

For the purpose of this report, the mixture of the above-listed media in proportion to their estimated volumes is referred to as the Material Blend. Detailed computations of estimated volumes of contaminated on-base ditch sediment are presented in Appendix A.

1.4 STUDY OBJECTIVES

The purpose of the bench-scale treatability study was to determine whether the contaminated media identified in Section 1.3 can be excavated and placed on Site 8A in such a manner that the consolidated Material Blend is suitable to support a structural cap. The area to receive the structural cap will ultimately be used for the parking and storage of heavy construction equipment. It was assumed that the structural cap would be designed to support Highway 20 (H20) loading, as defined by the American Association of State Highway and Transportation Officials (AASHTO, 1973). The consolidated material must therefore have sufficient load-bearing capacity to support the structural cap and H20 loading. To determine this, the consolidated Material Blend was evaluated for compaction and load-bearing characteristics during this treatability study.

The objectives of the bench-scale treatability study were as follows:

- Determine the compaction and load-bearing characteristics of the Material Blend.
- Determine if and to what extent the compaction and load-bearing characteristics of the Material Blend are affected by an increase in the content of its weakest component, i.e., sediment.
- Determine if and to what extent the compaction and load-bearing characteristics of the Material Blend are improved by amendment with binding/stabilization agents.

1.5 STUDY PLAN

To achieve the above objectives, the following sequential tasks were planned for the bench-scale treatability study:

- Computation of volumes of contaminated media as presented in Section 1.3.
- Collection of representative samples of contaminated media and shipment of these samples to the TtNUS Pittsburgh testing facility.
- Pre-testing of samples at the TtNUS Pittsburgh testing facility, including removal of free water, screening, moisture content measurement, and mixing of the media samples in the proper proportions to obtain the Material Blend.

- First-tier testing of the Material Blend by a specialized geotechnical laboratory (i.e., Geotechnics) to measure the compaction and load-bearing characteristics.

- Second-tier testing of the Material Blend by Geotechnics:

  - If the results of the first-tier testing showed the compaction and load-bearing characteristics of the Material Blend to be acceptable, the second-tier testing was to consist of measuring the compaction and load-bearing of a Material Blend with increased sediment content.

  - If the results of the first-tier testing showed the compaction and load-bearing characteristics of the Material Blend to be unacceptable, the second-tier testing was to consist of measuring the compaction and load-bearing characteristics of a Material Blend amended with binding/stabilization agents.

- Third-tier testing of the Material Blend by Geotechnics-Third-tier tests were to gauge the sensitivity of the results of the second-tier testing of a Material Blend amended with the preferred binding agent by measuring the compaction and load-bearing characteristics of this amended Material Blend with increased sediment content.

1.6 DOCUMENT ORGANIZATION

This report is organized into the following seven sections:

- Section 1.0 provides this brief introduction.

- Section 2.0 describes the field sampling and collection of the materials to be tested.

- Section 3.0 describes and presents the results of the pre-testing activities, including free water separation, screening, proportional blending of contaminated media, and measurement of moisture contents.

- Sections 4.0 to 6.0 describe and present the results of the first-, second-, and third-tier testing, respectively.

- Section 7.0 presents conclusions and recommendations.

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2.0 SAMPLE COLLECTION

Representative samples of incinerated soil ash, on-base drainage ditch sediment, and off-base swampland sediment were collected. Each of these three media was manually collected using a hand shovel and containerized separately in U.S. Department of Transportation (DOT) approved 5-gallon plastic buckets labeled to identify their contents.

In addition to the above-listed materials, approximately 10 gallons of Type F fly ash were obtained from a Gulfport area electric power generating station and approximately 10 gallons of Portland Cement were also obtained locally for use as binding agents. It should be noted that in the draft version of this report (TtNUS, 2000b), this Portland Cement had been mistakenly identified as cement kiln dust (CKD), which has a very similar physical appearance.

The following sections provide a brief description of the incinerated soil ash, on-base ditch sediment, and off-base swampland sediment collected for the investigation. Photographs of the sampling locations and materials collected and used during the bench-scale treatability study are presented in Appendix B.

2.1 INCINERATED SOIL ASH

Approximately 50 gallons of incinerated soil ash were collected from the Site 8A location shown on Figure 1-1. The soil ash present at Site 8A is a result of incineration operations that were conducted in the late 1980s to remediate dioxin-contaminated soils at Site 8 (HLA, 2000). The soil ash can be described as a black, fine-grained silty sand. Gravel has been placed atop the soil ash piles to reduce wind erosion of the ash. The soil ash present throughout Site 8A is relatively uniform in nature.

2.2 ON-BASE DRAINAGE DITCH SEDIMENT

Approximately 60 gallons of sediment were collected from the on-base drainage ditches at the locations shown on Figure 2-1. Two different sediment types were observed during sample collection. In the upper reaches of the drainage ditch system, the prevalent sediment type can be described as a fine-grained sandy type. In the lower reaches of the drainage ditch system, where free-standing water is observed year round, material consisting of decayed organic matter and settled fines was observed in the upper layer of the sediment. The material below the organic fines can be described as saturated sand similar in type to that found in the upper reaches of the drainage ditch system. Samples of dry and saturated sand, This page intentionally left blank.

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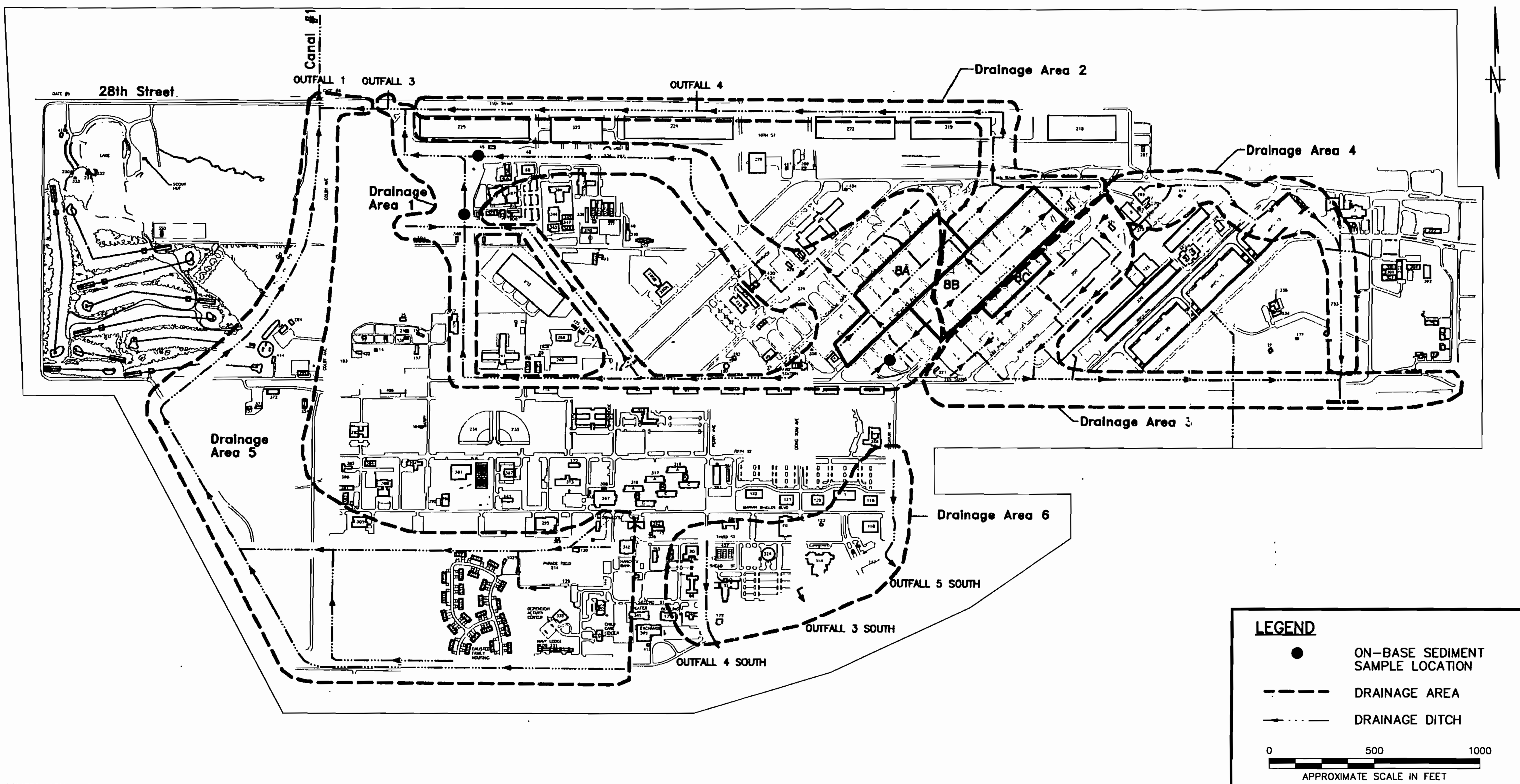

SOURCE: REMEDIATION GUIDANCE DOCUMENT, HARDING LAWSON ASSOCIATES, MARCH 2000.

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ON-BASE SEDIMENT SAMPLING LOCATIONS
NAVAL CONSTRUCTION BATTALION CENTER
GULFPORT, MISSISSIPPI

CONTRACT NO. 0567	
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DRAWING NO. FIGURE 2-1	REV. 0

FORM CADD NO. SDIV_BH.DWG - REV 0 - 1/20/98 and organic fines were collected. Vegetative matter was observed at varying concentrations in all on-base ditch sediment samples.

Significant free water was also observed in the on-base ditch sediment. Samples were collected in such a way as to include an estimated amount of water representative of that expected to remain in the sediment if the material was removed with typical excavation equipment, such as a gradall.

2.3 OFF-BASE SWAMPLAND SEDIMENT

Approximately 30 gallons of sediment were collected from the off-base drainage system within the swampland located north of NCBC Gulfport at the locations shown on Figure 2-2. The off-base swampland sediment can be described as a fine-grained silty clay. Additionally, the off-base swampland sediment contained small amounts of vegetative matter (e.g., roots, small twigs).

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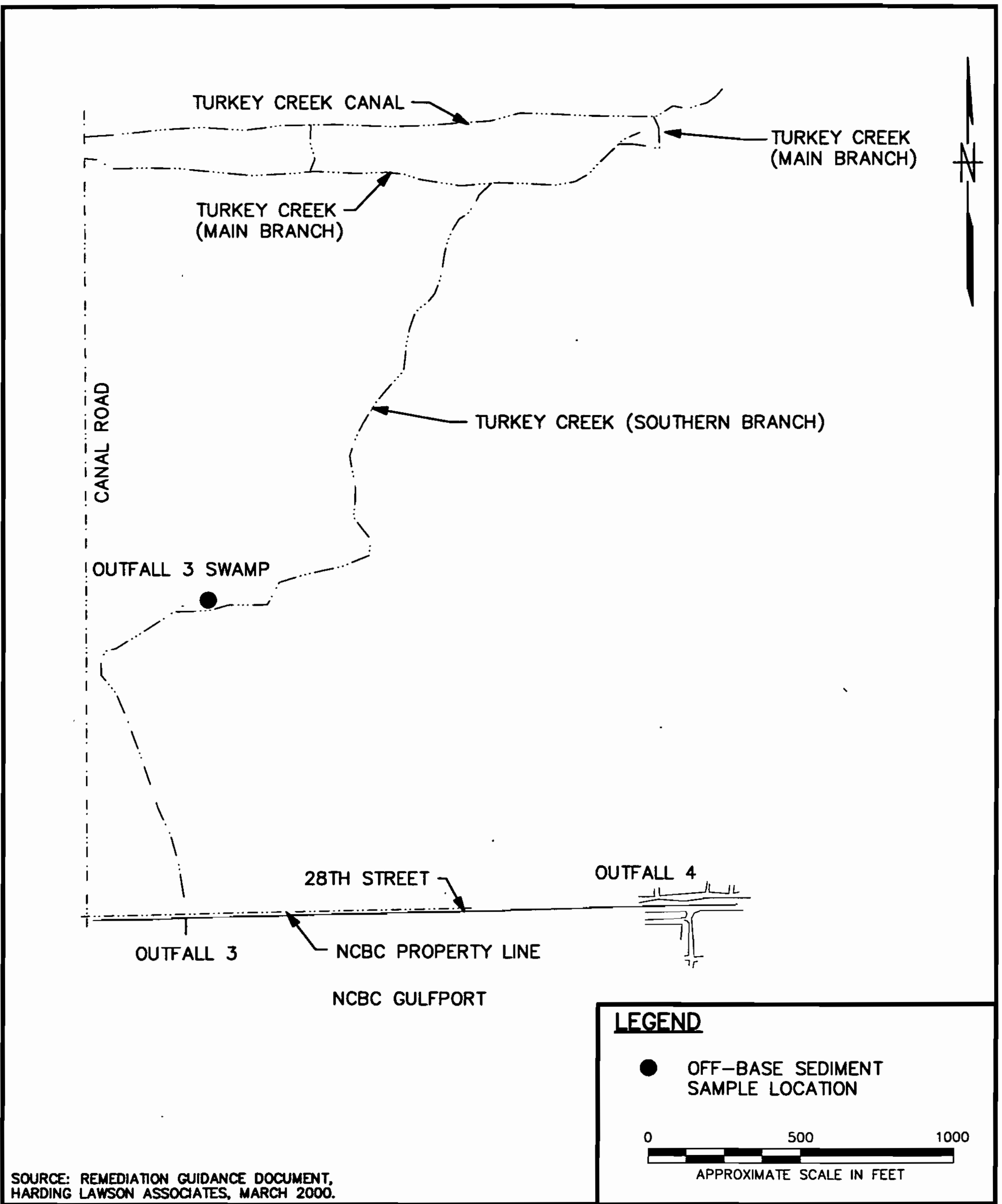

SOURCE: REMEDIATION GUIDANCE DOCUMENT, HARDING LAWSON ASSOCIATES, MARCH 2000.

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3

3.0 SAMPLES PRE-TESTING

Upon receipt of the sample materials at the TtNUS Pittsburgh testing facility, free-standing water was decanted from the sample containers, the material was screened using a ¾-inch sieve, and the samples were blended. Additionally, moisture contents were measured for each of the individual soil types and the resulting Material Blend. A discussion of each of these activities is presented in the following sections.

3.1 FREE WATER SEPARATION

Upon receipt of the on-base sediment, approximately 1 to 4 inches of free-standing water was observed in the top portions of the 5-gallon buckets that contained the on-base ditch sediment. Prior to screening and blending, free-standing water was decanted from these containers. Water was removed in such a way as to approximate the volume of water that would be removed through dewatering during full-scale operations. No free-standing water or excessive moisture was observed in the buckets that contained off-base swampland sediment or soil ash, due to dry field conditions.

3.2 SCREENING

Prior to blending, each material type was screened through a ¾ -inch sieve to remove oversized particles and debris. For the soil ash, oversized material remaining on the sieve consisted primarily of the gravel that was placed atop of the Site 8A soil ash piles to prevent wind erosion. For the off-base swampland and on-base ditch sediment, oversized material consisted primarily of root and other vegetated matter. Because screening of the on-base ditch sediment yielded very little oversized material and proved to be a relatively sloppy operation, only about half of that sediment was screened. On average, approximately 5 percent by volume of the screened material was retained on the ¾-inch screen.

3.3 BLENDING

After screening, each material type (i.e., soil ash, off-base sediment, and on-base sediment) was blended separately in a small-scale rotary-type concrete mixer to create a representative blend for each soil type. For example, the ten, 5-gallon containers of soil ash were placed in the cement mixer and mixed for approximately 15 minutes to create a uniform mixture. The blend of off-base swamp sediment was also prepared in a similar manner. A photograph of the concrete mixer is presented in Appendix B.

The on-base ditch sediment mixture was created using a blend of the following volumetric fractions: saturated sand-60 percent; dry sand-20 percent; and saturated fine-grain silty clay-20 percent. Based on drainage ditch field measurements and field observations, this estimate is believed to be representative of the 24,000 cubic yards of on-base sediment that is to be excavated. A detailed computation of this estimate is provided in Appendix A.

Upon completion of mixing, each soil type was placed in a 55-gallon drum for use in later phases of bench-scale testing.

Based on the volumes of contaminated media estimated in Section 1.3, the Material Blend was created using the following proportions of soil ash, on-base ditch sediment, and off-base swampland sediment.

Material	**Estimated Volume** (yd^3)	Percent of Material Blend
Site 8A Incinerated Soil Ash	21,000	36.2
On-Base Ditch Sediment	24,000	41.4
Off-Base Swampland Sediment	13,000	22.4
Total	**58,000**	**100**

3.4 MOISTURE CONTENT MEASUREMENTS

After blending, the moisture content of the three individual contaminated media and of the Material Blend were measured in accordance with the American Society for Testing and Materials (ASTM) Method D2216. The results of the moisture content testing are provided as follows:

Material	Moisture Content (%wt)
Soil Ash	7.2
On-Base Ditch Sediment	24
Off-Base Swampland Sediment	16.3
Material Blend	18.3

A copy of ASTM Method D2216 is provided in Appendix C. Moisture content measurement data sheets are provided in Appendix D.

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4.0 FIRST-TIER TESTING

4.1 INTRODUCTION

The purpose of the first-tier testing was to determine whether the pre-treated Material Blend (i.e., after removal of free water and screening) would have compaction and load-bearing characteristics that satisfy the AASHTO H20 loading criteria and could thus be consolidated on Site 8A without further treatment. To this effect, the pre-treated Material Blend was submitted to Geotechnics to measure moisture-density relationship and California Bearing Ratio (CBR).

The CBR test was selected for use during this bench-scale treatability study because this test provides one of the most commonly used criterion for determining of the load-bearing capacity of treated or untreated soil. A CBR measurement of 20 was selected as a gauge of acceptance or failure since this value is typically considered as a threshold value for satisfying the AASHTO H20 loading criteria.

4.2 MOISTURE-DENSITY RELATIONSHIP TEST

The as-received/as-mixed moisture content of the pre-treated Material Blend was first measured to be 20.3 percent by weight in accordance with ASTM Method D2216.

The moisture-density relationship of the pre-treated Material Blend was then determined in accordance with ASTM Method D698 (Procedure B) to determine optimum moisture content and maximum dry density. Results of this test can be summarized as follows:

Material Blend	Optimum Moisture Content (wt %)	Maximum Dry Density (lbs/ft^3)
GFP-08-MB-01	12.8	113.2

A copy of ASTM Method D698 is provided in Appendix C. Detailed laboratory data sheets for the first-tier moisture-density relationship test are provided in Appendix E.

4.3 CALIFORNIA BEARING RATIO TESTS

The CBR of the pre-treated Material Blend was measured in accordance with ASTM Method D1883 (Molding Procedure C, as per ASTM Method D698) under both as-mixed (i.e., 20.3% moisture) and optimum (i.e., 12.8% moisture) conditions. Results of these tests can be summarized as follows:

Material Blend	As-Molded Moisture Content (wt%)	As-Molded Density (lbs/ft^3)	As-Molded % of Max. Dry Density	CBR(1)	
				0.1" penetration	0.2" penetration
As-Mixed Conditions	20.3	101.2	89.4	1	1
Optimum Conditions	12.8	107.3	94.8	12	12

(1) CBR values are rounded to the nearest whole number if below 20 and to the nearest 5 if above 20.

A copy of ASTM Method D1883 is provided in Appendix C. Detailed laboratory data sheets for the first-tier CBR tests are provided in Appendix E.

4.4 CONCLUSIONS

The following conclusions were drawn from the above test results:

- Under as-mixed conditions, the moisture content of the pre-treated Material Blend was measured between 18.3 and 20.3 percent (by weight), which is significantly higher than the 12.8 percent value that was determined to be optimum for compaction.

- Under as-mixed moisture conditions (i.e., 20.3%), the CBR of the pre-treated Material Blend was 1, which is considerably lower than the 20 that is typically considered as a threshold value for satisfying the AASHTO H20 loading criteria. Therefore, under as-mixed conditions the pre-treated Material Blend is unacceptable for consolidation under a structural cap at Site 8A.

- Since the load-bearing characteristics of the Material Blend are unsuitable under as-mixed moisture conditions (i.e., 20.3%), a decision was made not to test the impact of an increase in the proportion of the sediment content of the Material Blend, since such an increase would result in a higher moisture content and deteriorate load bearing characteristics even further.

- Under optimum moisture conditions (i.e., 12.8 %), the CBR of the pre-treated Material Blend increased to 12, which is much improved but still significantly below the threshold value of 20. Therefore, even under optimum moisture conditions the pre-treated Material Blend would still not be acceptable for consolidation under a structural cap at Site 8A.

- Reducing the moisture content of the Material Blend from its as-mixed value of 20.3 percent to its optimum value of 12.8 percent would probably require relatively complex and costly mechanical dewatering operations with equipment such as filter presses or vacuum filters.

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5.0 SECOND-TIER TESTING

5.1 INTRODUCTION AND DESIGN MIXES

As concluded from the results of the first-tier testing, the load-bearing characteristics of the pre-treated Material Blend must be improved if this material is to be acceptable for consolidation under a structural cap at Site 8A. It was judged that the simplest and most economical method to achieve this improvement is the addition of a binding agent.

Accordingly, the purpose of the second-tier testing was to determine what type and quantity of binding agent would have to be added to increase the CBR of the Material Blend above the threshold value of 20.

Two types of binding agents were selected for testing: Type F fly ash and Portland Cement. These agents were selected based upon past experience with similar projects, local availability, and cost.

As noted earlier, it had originally been planned to use CKD rather than Portland Cement as the second test binding agent (TtNUS, 2000a) and, as indicated in the draft version of this report (TtNUS, 2000b), it was believed that 10 gallons of CKD had been obtained locally for this purpose. However, post-testing inquiries revealed that the locally obtained material had in fact been Portland Cement that has a very similar physical appearance to CKD. Nevertheless, since not only the physical appearance but also the pozzolanic characteristics of Portland Cement are similar to those of CKD, substitution of one binding agent for the other did not in fact constitute a significant deviation in testing procedures.

The following design mixes were prepared and tested for moisture-density relationship and CBR by Geotechnics:

Design Mix No.	Composition (%, by weight)
GFP-08-MB-02-FA05	95% Material Blend + 5% Fly Ash
GFP-08-MB-02-FA10	90% Material Blend + 10% Fly Ash
GFP-08-MB-02-FA15	85% Material Blend + 15% Fly Ash
GFP-08-MB-02-PC05	95% Material Blend + 5% CKD
GFP-08-MB-02-PC10	90% Material Blend + 10% Portland Cement
GFP-08-MB-02-PC15	85% Material Blend + 15% Portland Cement

5.2 MOISTURE-DENSITY RELATIONSHIP TESTS

The moisture-density relationship of the above-listed design mixes was measured in accordance with ASTM Method D698 (Procedure B). Results of these tests can be summarized as follows:

Design Mix No.	Optimum Moisture Content (%wt)	Maximum Dry Density (lbs/ft^3)
GFP-08-MB-02-FA05	12.6	111.9
GFP-08-MB-02-FA10	12.9	110.8
GFP-08-MB-02-FA15	12.7	109.1
GFP-08-MB-02-PC05	13.4	112.2
GFP-08-MB-02-PC10	13.7	112.0
GFP-08-MB-02-PC15	13.6	111.9

Detailed laboratory data sheets for the second-tier moisture-density relationship tests are provided in Appendix F.

5.3 CALIFORNIA BEARING RATIO TESTS

The CBR values of the above-listed design mixes were measured under as-mixed, or as-molded, moisture conditions in accordance with ASTM Method D1883 (Molding Procedure C as per ASTM Method D698). Results of these tests can be summarized as follows:

Design Mix No.	As-Molded Moisture Content (wt%)	As-Molded Dry Density (lbs/ft^3)	As-Molded % of Max. Dry Density	CBR(1)	
				0.1" penetration	0.2" penetration
GFP-08-MB-02-FA05	19.5	102.9	92.0	1	1
GFP-08-MB-02-FA10	17.6	103.9	93.8	1	2
GFP-08-MB-02-FA15	16.7	103.4	94.8	2	3
GFP-08-MB-02-PC05	18.9	104.9	93.5	35	40
GFP-08-MB-02-PC10	17.3	107.8	96.3	105	115
GFP-08-MB-02-PC15	17.2	110.0	98.3	160	180

(1) CBR values are rounded to the nearest whole number if below 20 and to the nearest 5 if above 20

Detailed laboratory data sheets for the second-tier CBR tests are provided in Appendix F.

5.4 CONCLUSIONS

The following conclusions were drawn from the above test results:

- The addition of fly ash did not appreciably improve the load bearing capacity of the Material Blend.

- The addition of Portland Cement significantly improved the load-bearing characteristics of the Material Blend. The addition of as little as 5 percent (by weight) of Portland Cement increased the CBR from approximately 1 to approximately 35 under as-mixed/as-molded moisture conditions. This is significantly above the threshold value of 20 that would meet the AASHTO H20 loading criteria. The addition of 10 and 15 percent of Portland Cement increased the CBR value even further.

- The addition of Portland Cement can make the Material Blend acceptable for consolidation under a structural cap at Site 8A.

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6.0 THIRD-TIER TESTING

6.1 INTRODUCTION AND DESIGN MIXES

As concluded from the results of the second-tier testing, the addition of a relatively small amount of Portland Cement (i.e., 5 to 10 percent) can improve the load-bearing characteristics of the Material Blend to the extent that the amended Material Blend exceeds the AASHTO H20 loading criteria.

Accordingly, the purpose of the third-tier testing was to gauge the sensitivity of the second-tier testing results to possible variations in the Material Blend composition as are likely to be experienced during full-scale remediation operations. In particular, third-tier testing was geared towards evaluating the impact of a significant increase in the proportion of sediment in the Material Blend, which is a likely occurrence under field conditions.

The following design mixes were prepared and tested for moisture-density relationship and CBR by Geotechnics:

Design Mix No.	Composition (%, by weight)
GFP-08-MB-03-PC05-SD15	80% Material Blend + 15% Sediment + 5% Portland Cement
GFP-08-MB-03-PC05-SD30	65% Material Blend + 30% Sediment + 5% Portland Cement
GFP-08-MB-03-PC10-SD15	75% Material Blend + 15% Sediment + 10% Portland Cement
GFP-08-MB-03-PC10-SD30	60% Material Blend + 30% Sediment + 10% Portland Cement

In addition, in order to provide additional geotechnical data on the Material Blend amended with Portland Cement with or without added sediment, the above-listed design mixes and two of the second-tier design mixes (GFP-08-MB-02-PC05 and GFP-08-MB-02-PC10) were tested for 3- and 7-day Unconfined Compressive Strength (UCS) by Geotechnics.

6.2 MOISTURE-DENSITY RELATIONSHIP TESTS

The moisture-density relationship of the above-listed design mixes was measured in accordance with ASTM Method D698 (Procedure B). Results of these tests can be summarized as follows:

Design Mix No.	Optimum Moisture Content (%wt)	Maximum Dry Density (lbs/ft^3)
GFP-08-MB-03-PC05-SD15	13.5	113.2
GFP-08-MB-03-PC05-SD30	13.1	114.6
GFP-08-MB-03-PC10-SD15	13.0	114.2
GFP-08-MB-03-PC10-SD30	13.3	113.3

Detailed laboratory data sheets for the third-tier moisture-density relationship tests are provided in Appendix G.

6.3 CALIFORNIA BEARING RATIO TESTS

The CBR values of the above-listed design mixes were measured under as-mixed/as-molded moisture conditions in accordance with ASTM Method D1883 (Molding Procedure C as per ASTM Method D698). Results of these tests can be summarized as follows:

Design Mix No.	As-Molded Moisture Content (wt%)	As-Molded Maximum Dry Density (lbs/ft^3)	As-Molded % of Max. Dry Density	CBR(1)	
				0.1" penetration	0.2" penetration
GFP-08-MB-03-PC05-SD15	19.8	103.8	91.7	60	55
GFP-08-MB-03-PC05-SD30	22.3	98.6	86.0	45	35
GFP-08-MB-03-PC10-SD15	20.4	103.8	90.9	115	110
GFP-08-MB-03-PC10-SD30	21.9	101.1	89.2	155	140

(1) CBR values are rounded to the nearest whole number if below 20 and to the nearest 5 if above 20.

Detailed laboratory data sheets for the third-tier CBR tests are provided in Appendix G.

6.4 UNCONFINED COMPRESSIVE STRENGTH TESTS

The 3- and 7-day UCS of the above-listed design mixes was measured under as-mixed moisture conditions in accordance with ASTM Method D2166. Results of these tests can be summarized as follows:

Design Mix No.	3-Day UCS(1)		7-Day UCS(1)	
	Load (lbs)	Stress (psi)	Load (lbs)	Stress (psi)
GFP-08-MB-02-PC05	199	28	402	57
GFP-08-MB-02-PC10	422	60	558	79
GFP-08-MB-03-PC05-SD15	154	22	279	39
GFP-08-MB-03-PC05-SD30	113	16	283	40
GFP-08-MB-03-PC10-SD15	313	44	1192	164
GFP-08-MB-03-PC10-SD30	276	39	509	72

(1) UCS values are rounded to the nearest whole number.

A copy of ASTM Method D2166 is provided in Appendix C. Detailed laboratory data sheets for the UCS tests are provided in Appendix G.

6.5 CONCLUSIONS

The following conclusions were drawn from the above test results:

- The 7-day UCS values of the Material Blend amended with either 5 or 10 percent Portland Cement are above the 50 pounds per square inch (psi), that is typically considered to be the threshold value for satisfying the AASHTO H20 loading criteria. Therefore, the results of the UCS tests confirm the results of the CBR tests.

- A significant increase in sediment content (i.e., 15 to 30%) has no appreciable negative effect on the CBR values of the Material Blend amended with either 5 or 10 percent Portland Cement, which remain acceptable.

- Material blend samples amended with additional sediment and 5 percent Portland Cement achieved 7-day UCS values below the 50 psi threshold value; however, it is judged that these samples would likely achieve 50 psi after 28 days of curing. Material blend samples amended with additional sediment and 10 percent Portland Cement achieved 7-day UCS values greater than 50 psi.

7

7.0 CONCLUSIONS AND RECOMMENDATIONS

7.1 CONCLUSIONS

The following conclusions were drawn from the results of the bench-scale treatability study:

- The compaction and load-bearing characteristics of the unamended Material Blend do not satisfy the AASHTO H20 loading criteria.

- Decreasing the moisture content of the Material Blend from its as-mixed percentage to its optimum percentage would most likely require mechanical dewatering and does not sufficiently improve compaction and load-bearing characteristics to satisfy AASHTO H20 loading criteria.

- The amendment of the Material Blend with Type F fly ash does not improve its compaction and load-bearing characteristics.

- The amendment of the Material Blend with 5 to 10 percent (by weight) of Portland Cement sufficiently improves its compaction and load-bearing characteristics to satisfy AASHTO H20 loading. In particular, the measured CBR and 7-day UCS for these amended Material Blends were significantly higher than the acceptable threshold values for these criteria.

- The compaction and load-bearing characteristics of the amended Material Blend are not unduly sensitive to an increase in sediment content, which is the most likely variation in the composition of the Material Blend to occur under field conditions. An increase of up to approximately 20 percent (by weight) in the sediment content of the amended Material Blend did not decrease the CBR but did result in lower UCS values. In the case of the Material Blend amended with 5 percent Portland Cement, an increase in sediment content lowered the measured 7-day UCS below the 50 psi threshold value. However, it is judged that these samples would likely achieve 50 psi after 28 days of curing.

7.2 RECOMMENDATIONS

The following recommendations are made based upon the results of the bench-scale treatability study:

- The Material Blend should not be consolidated under a structural cap at Site 8A without amendment using a binding agent.

- The Material Blend should be amended with 5 to10 percent by weight of Portland Cement prior to placement under the Site 8A structural cap.

- A pilot-scale treatability study should be performed to verify the technical feasibility, and identify the best-suited methods, of implementing the findings of the bench-scale treatability study on a scale representative of actual remedial operations. As part of this pilot-scale treatability study, additional testing should be performed to determine whether free water needs to be removed from the excavated sediment, since this free water may not adversely impact the compaction and load-bearing characteristics of the amended Material Blend.

REFERENCES

AASHTO (American Association of State Highway and Transportation Officials), 1973. *Standard Specifications for Highway Bridges.* Eleventh Edition.

ABB-ES (ABB Environmental Services), 1998. *Surface Water and Sediment Dioxin Selineation, NCBC Gulfport, Mississippi.* Prepared for SOUTHDIVNAVFACENGCOM, North Charleston, South Carolina. July.

HLA (Harding Lawson Associates, Inc.), 2000. *Remediation Planning Document, Naval Construction Battalion Center Gulfport, Mississippi.* Prepared for SOUTHNAVFACENGCOM, North Charleston, South Carolina. August.

MSDEQ (Mississippi Department of Environmental Quality), 1997. *Agreed Order No. 3466-97.* November.

TtNUS (Tetra Tech NUS, Inc.), 2000a. *Work Plan, Bench-Scale Soil/Sediment Treatability Study, Site 8, Herbicide Orange Study Area at Naval Construction Battalion Center, Gulfport, Mississippi.* Prepared for SOUTHDIVNAVFACENGCOM, Charleston, South Carolina. October.

TtNUS, 2000b. *Draft Report, Bench-Scale Soil/Sediment Treatability Study, Site 8, Herbicide Orange Study Area at Naval Construction Battalion Center, Gulfport, Mississippi.* Prepared for SOUTHDIVNAVFACENGCOM, North Charleston, South Carolina. November.

A

APPENDIX A

CONTAMINATED ON-BASE DITCH SEDIMENT VOLUMES COMPUTATIONS

Client: NCBC Gulfport		**Job Number** N0567	
Subject: Volume of Contaminated On-Base Sediment Calculation			
Based On: TtNUS Field Measurements and Observations; HLA Areal Extent of Contamination			
By: J. Brown	**Checked By:** JRM 11-3-00		**Date:** November 2, 2000

Purpose:

1. To estimate the volume of on-base sediment in the drainage ditch system originating from Site 8.
2. To estimate the composition of dry sand, saturated sand, and organic fines in the on-base sediment to be excavated.

Approach: The following approach is taken:

- The area of impacted sediment (delineated to 50 ppt) as presented in HLA, 2000 is assumed. This area of impacted sediment is illustrated in Figure A-1.

- Dimensions of drainage ditches were measured in August 2000. The width of the drainage ditch and the vertical depth from the top of bank to the top of ditch sediment were measured. Additionally, an estimate of the depth of sediment that would be excavated was made at this time. These measurements/estimations are presented in Table A-1. A cross section of the drainage ditch is provided in Figure A-2.

- The drainage ditches were segmented based on locations where field measurements were taken. Based on field measurements, field observations, and the areal extent of contamination assumed in HLA, 2000, volumes were calculated. The composition of dry sand, saturated sand, and organic fines were estimated based on the assumptions listed in the following section.

Assumptions: The following assumptions are made:

- The drainage ditch has a cross section as presented in Figure A-2 with 45-degree side slopes.

- On the sides of the drainage ditches, a 1-foot depth of excavation is assumed.

- The bottom third of the drainage ditch side is comprised of saturated sand and the top two thirds is comprised of dry sand.

- Organic fines are assumed to be located in the top 1 foot of sediment in the lower reaches of the drainage ditch system (areas where standing water is present year round). Below the organic fines, the sediment is assumed to be comprised of saturated sandy soil.

Equations: Equations used in the calculation are presented in Figure A-2.

Client: NCBC Gulfport		**Job Number** N0567	
Subject: Volume of Contaminated On-Base Sediment Calculation			
Based On: TtNUS Field Measurements and Observations; HLA Areal Extent of Contamination			
By: J. Brown	**Checked By:** JRW 11-3-00		**Date:** November 2, 2000

Calculations: Calculations are presented in Table A-1. The results are summarized as follows.

Volume of On-base Sediment = 24,200 cubic yards

Composition of On-base Sediment

Dry Sand	18.8 percent ~ 20 percent
Saturated Sand	62.6 percent ~ 60 percent
Organic Fines	18.7 percent ~ 20 percent

References:

Harding Lawson Associates, 2000. Remediation Planning Document (Site 8). Naval Construction Battalion Center, Gulfport, Mississippi, August.

TABLE A-1

Assumptions

- Thickness of excavation on sides of ditches (ft) = 1
- Thickness of organic fines at base (ft) = 1

Drainage Area 1

Stream Segment	Soil Composition	Width (W)	Vertical Depth from Top of Bank to Top of Sediment (T)(ft)	Excavation Thickness (D) (ft)	Segment Length (L) (ft)	Volume of Sand (Dry) (ft3)	Volume of Sand (Sat) (ft3)	Volume of Organic Fines (ft3)	Volume Total (ft3)	Excavation Volume (cy)
1	sand	11	2	2	800	3,017	12,708	0	15,725	582
2	sand	11	3	2	600	3,394	7,697	0	11,091	411
3	sand	14	3	3	600	3,394	16,097	0	19,491	722
4	sand	10	2	3	200	754	3,977	0	4,731	175
5	sand	9	3	4	690	3,903	10,232	0	14,135	524
6	sand	22	4	2	240	1,810	7,625	0	9,435	349
7	sand	16	4	2	740	5,581	14,631	0	20,212	749
8	sand	13	3	2	1050	5,940	17,670	0	23,609	874
9	sand	16	5	2	240	2,263	4,011	0	6,274	232
10	organic/sand	22	5.5	2	900	9,334	14,567	9,900	33,801	1,252
11	organic/sand	22	5	2	430	4,054	7,187	5,160	16,401	607
12	organic/sand	30	5	3	2150	20,270	96,135	43,000	159,405	5,904
13	organic/sand	24	5	3	280	2,640	9,160	3,920	15,720	582
14	organic/sand	22	5	3	660	6,222	18,951	7,920	33,094	1,226
15	organic/sand	21	6	4	300	3,394	9,797	2,700	15,891	589
16	organic/sand	24	5	3	2100	19,799	68,699	29,400	117,898	4,367
17	sand	11	2	3	700	2,640	16,020	0	18,660	691
						98,409	335,165	102,000	535,574	19,836

Drainage Area 2

Stream Segment	Soil Composition	Width (W)	Vertical Depth from Top of Bank to Top of Sediment (T)(ft)	Excavation Thickness (D) (ft)	Segment Length (L) (ft)	Volume of Sand (Dry) (ft3)	Volume of Sand (Sat) (ft3)	Volume of Organic Fines (ft3)	Volume Total (ft3)	Excavation Volume (cy)
A	sand	7	2	2	370	1,395	2,918	0	4,313	160
B	sand	8	2.5	2	340	1,603	2,841	0	4,444	165
C	sand	13	3	2	440	2,489	7,404	0	9,893	366
D	sand	11.5	2.5	2	450	2,121	6,911	0	9,032	335
E	sand	12	2	2	470	1,772	8,406	0	10,179	377
F	organic/sand	8	1.5	2	580	1,640	3,720	2,900	8,261	306
G	organic/sand	23	3	2	400	2,263	7,931	6,800	16,994	629
H	organic/sand	25	5	2	0	-	-	-	-	-
I	organic/sand	24	4	2	650	4,903	12,851	10,400	28,154	1,043
J	sand	11	2.5	2	830	3,913	11,916	0	15,829	586
K	sand	11	2	2	550	2,074	8,737	0	10,811	400
						24,173	73,637	20,100	117,910	4,367

	Volume of Sand (Dry) (ft3)	Volume of Sand (Sat) (ft3)	Volume of Organic Fines (ft3)	Volume Total (ft3)	Excavation Volume (cy)
TOTALS	**122,583**	**408,801**	**122,100**	**653,484**	**24,203**
% material	18.8%	62.6%	18.7%	100%	

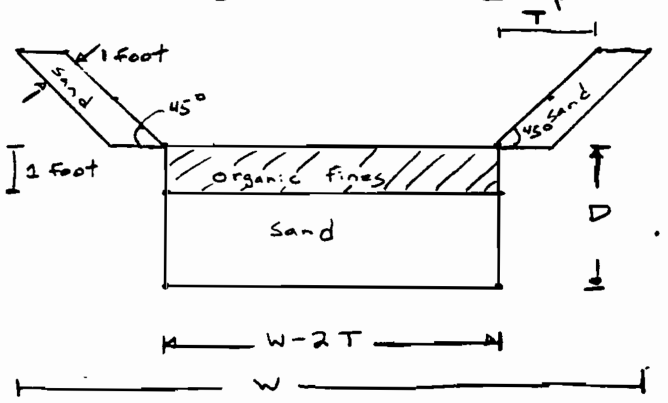
page 3 of 5

CHK'D ?RW 11-3-0

CLIENT		JOB NUMBER	
SUBJECT			
BASED ON		DRAWING NUMBER	
BY	CHECKED BY fLW 11-3-00	APPROVED BY	DATE

Figure A-2

Areas where organic fines are present



- Assume bottom 1/3 of T is saturated sands
- Assume 45° side slopes

Equations:

length of segment

Volume of Organic fines = $(W-2T)(1\ \text{foot})(L)$

Volume of Sat. Sand = $[(W-2T)(D-1) + \frac{1}{3}(2\sqrt{2}\ T)(1\ \text{ft})](L)$

Volume of Dry Sand = $(\frac{2}{3})(2\sqrt{2}\ T)(1\ \text{ft})(L)$

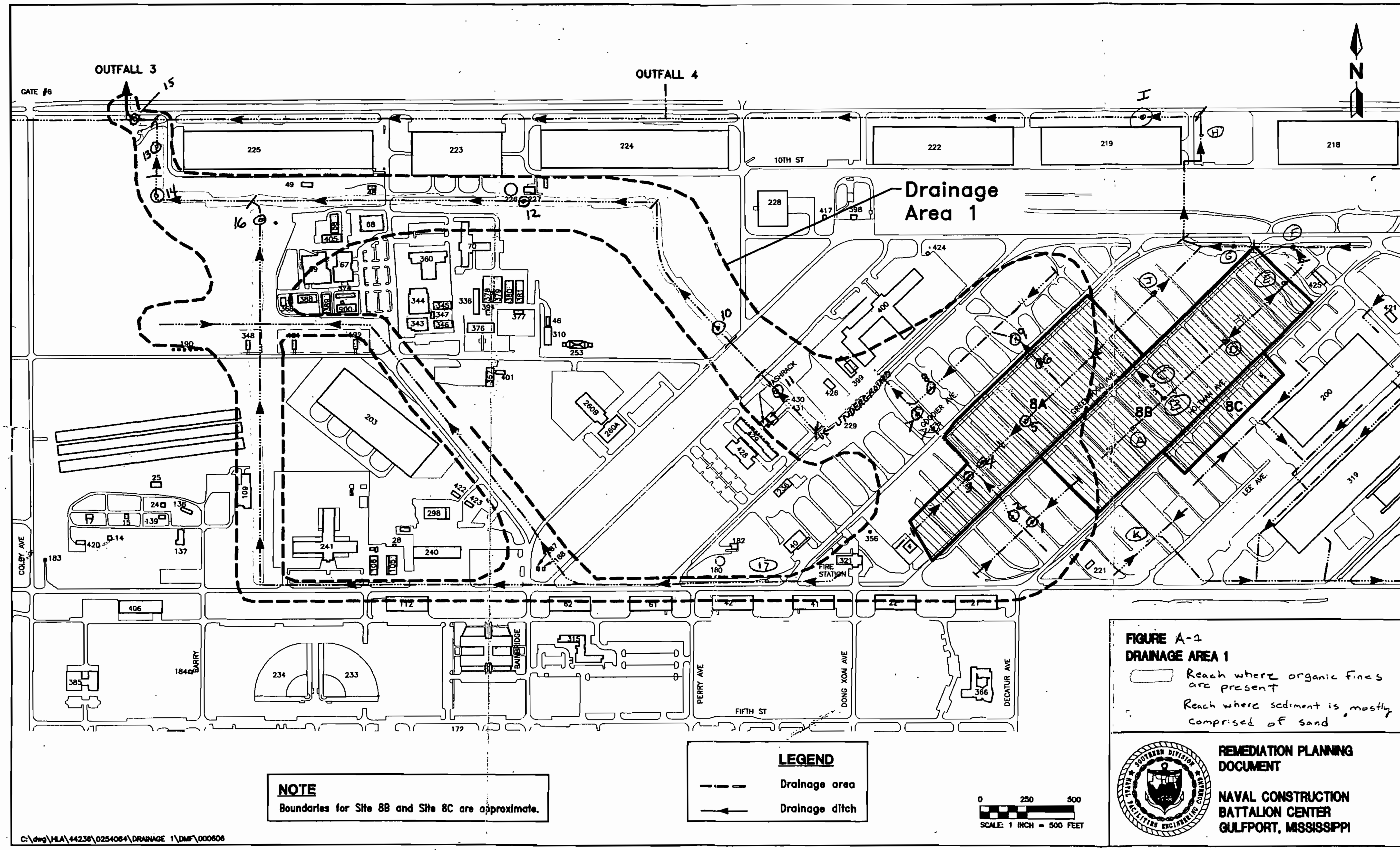
For areas comprised of sandy soil,

- assume depth D consists of saturated sands

Equations:

Volume of Saturated Sand = $[(W-2T)(D) + \frac{1}{3}(2T\sqrt{2})(1\ \text{ft})(L)$

Volume of dry sand = $(\frac{2}{3})(2\sqrt{2})(T)(1\ \text{ft})(L)$


OUTFALL 3
GATE #6
OUTFALL 4
N
10TH ST
Drainage Area 1
8A
8B
8C
WASHRACK
UNDERGROUND
FIRE STATION
COLBY AVE
BARRY
BAINBRIDGE
PERRY AVE
DONG XOAI AVE
DECATUR AVE
FIFTH ST
GREENWOOD AVE
HOLTMAN AVE
GOODIER AVE
LEE AVE
NOTE
Boundaries for Site 8B and Site 8C are approximate.
LEGEND
Drainage area
Drainage ditch
0 250 500
SCALE: 1 INCH = 500 FEET
FIGURE A-1
DRAINAGE AREA 1
Reach where organic fines are present
Reach where sediment is mostly comprised of sand
REMEDIATION PLANNING DOCUMENT
NAVAL CONSTRUCTION BATTALION CENTER
GULFPORT, MISSISSIPPI
C:\dwg\HLA\44236\0254064\DRAINAGE 1\DMF\000606

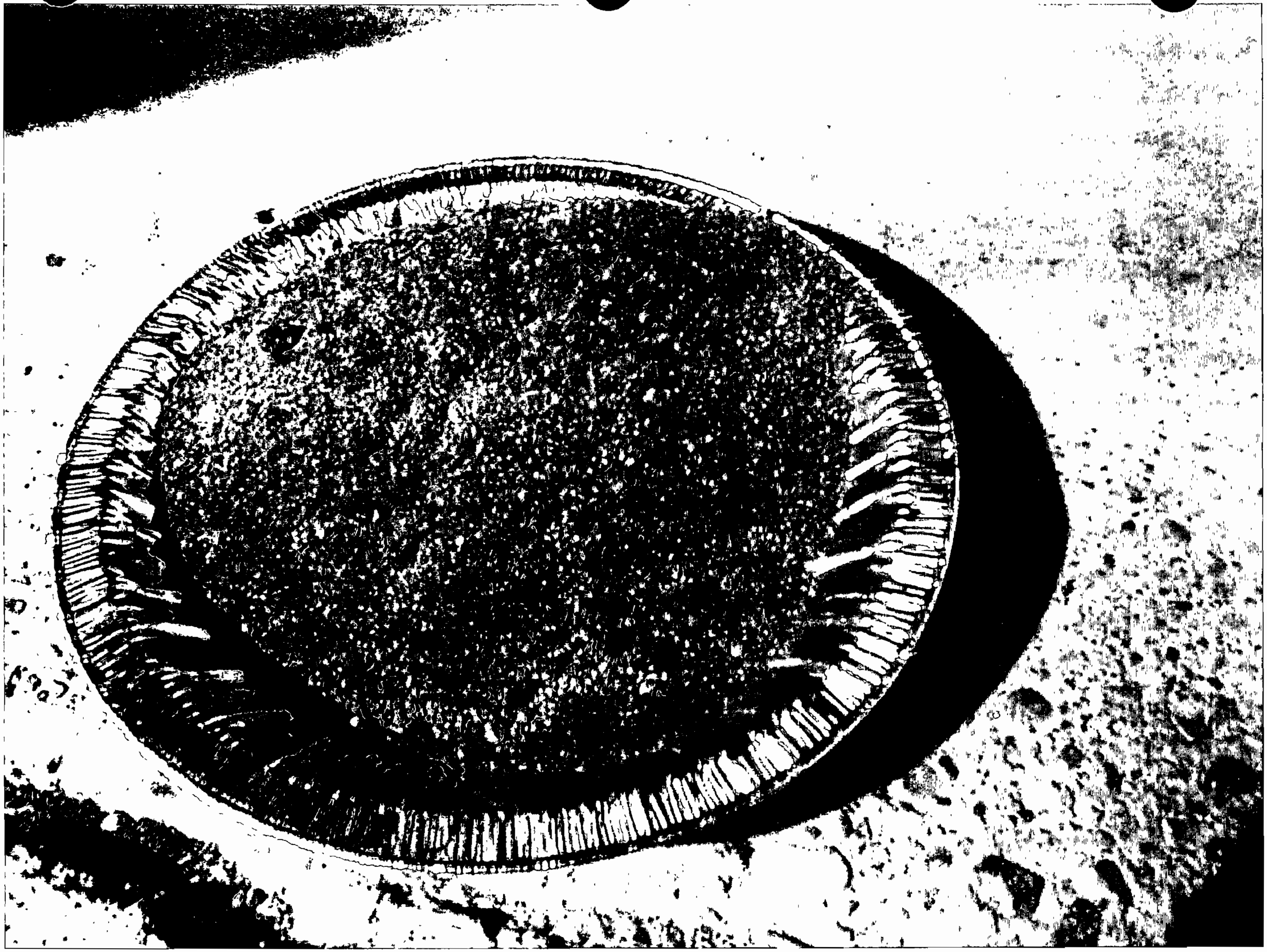
B

APPENDIX B

PHOTOGRAPHS

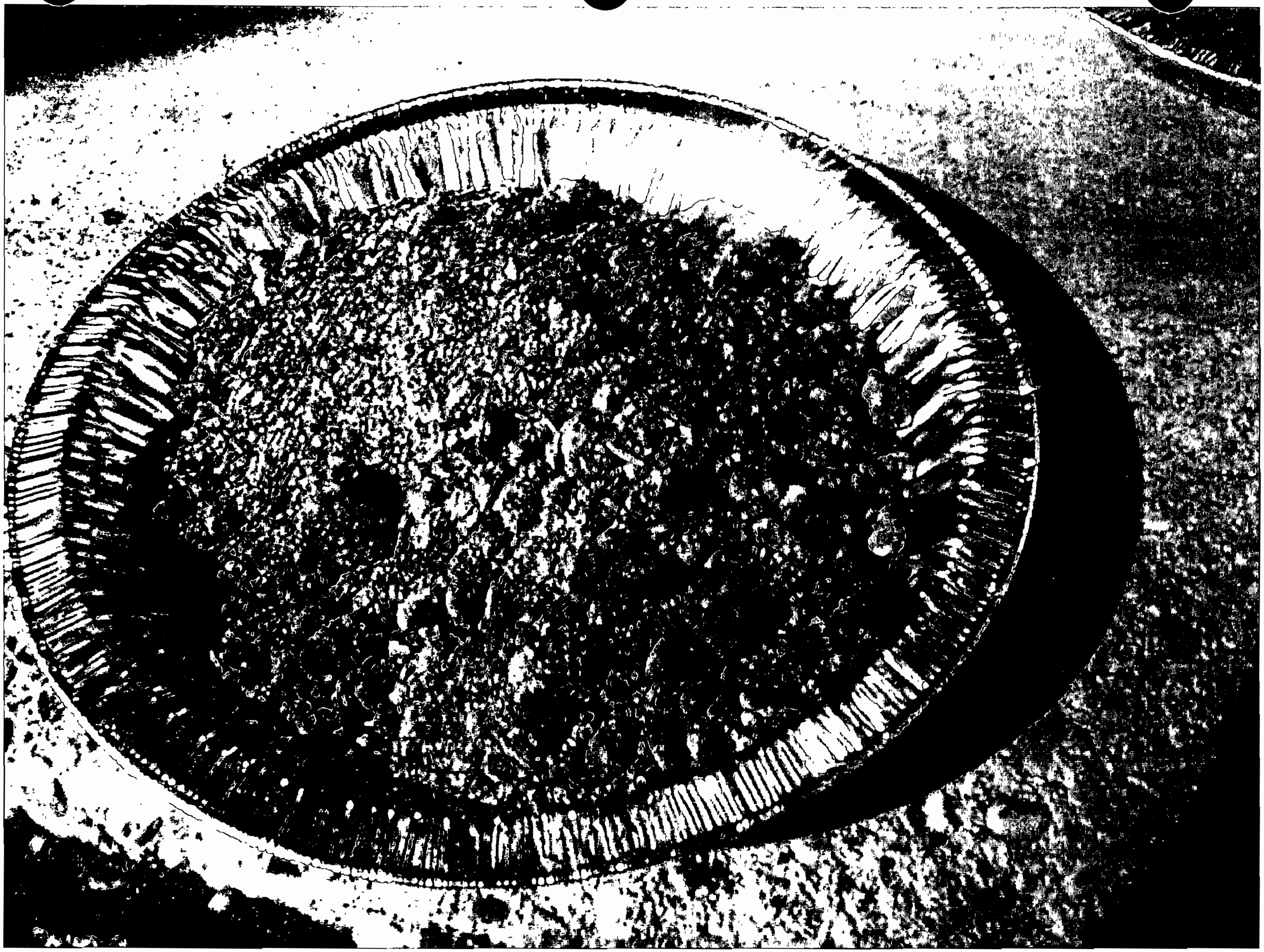
SAMPLING LOCATION - OFF-BASE SWAMPLAND SEDIMENT

SAMPLING LOCATION - ON-BASE DRAINAGE DITCH SEDIMENT

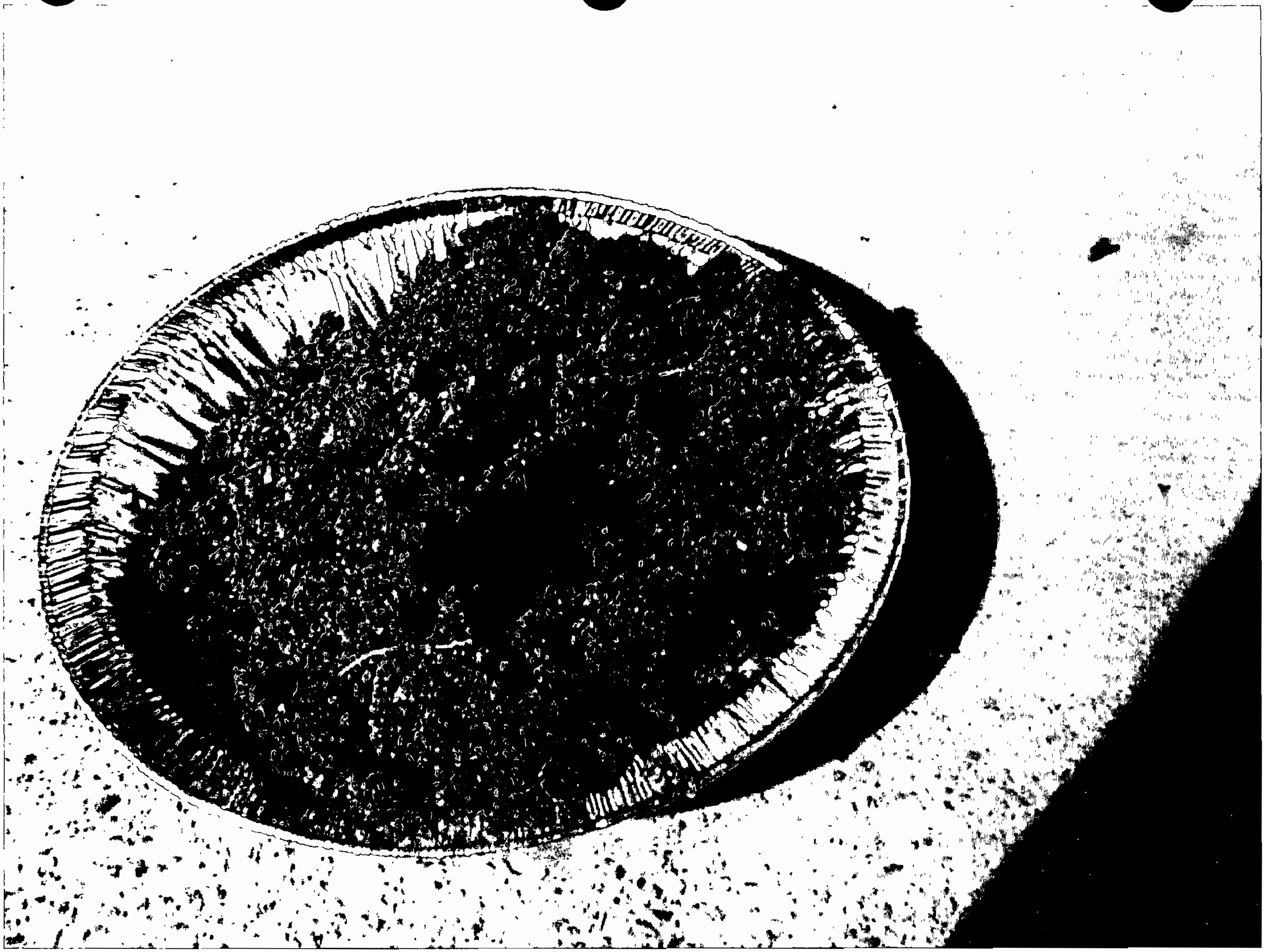


INCINERATED SOIL ASH

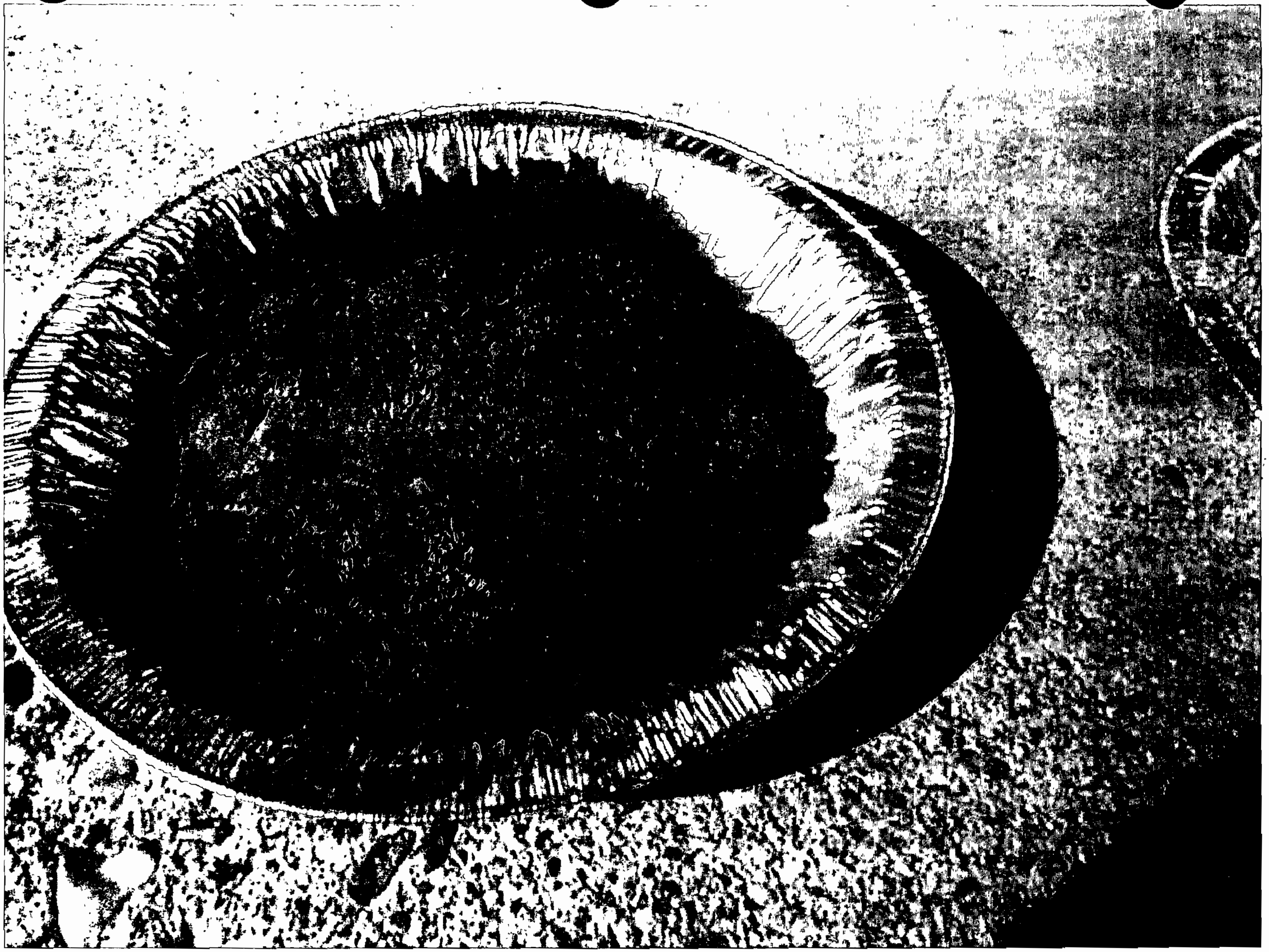
ON-BASE DITCH SEDIMENT



OFF-BASE SWAMPLAND SEDIMENT



MATERIAL BLEND



FLY ASH

PORTLAND CEMENT

ROTARY-TYPE CEMENT MIXER

C

APPENDIX C

ASTM TEST METHODS

Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3(600 kN-m/m^3))[1]

This standard is issued under the fixed designation D 698; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method covers laboratory compaction procedures used to determine the relationship between water content and dry unit weight of soils (compaction curve) compacted in a 4 or 6-in. (101.6 or 152.4-mm) diameter mold with a 5.5-lbf (24.4-N) rammer dropped from a height of 12 in. (305 mm) producing a compactive effort of 12,400 ft-lbf/ft^3(600 kN-m/m^3).

NOTE 1—The equipment and procedures are similar as those proposed by R. R. Proctor (*Engineering News Record*—September 7, 1933) with this one major exception: his rammer blows were applied as "12 inch firm strokes" instead of free fall, producing variable compactive effort depending on the operator, but probably in the range 15,000 to 25,000 ft-lbf/ft^3 (700 to 1,200 kN-m/m^3). The standard effort test (see 3.2.2) is sometimes referred to as the Proctor Test.

NOTE 2—Soils and soil-aggregate mixtures should be regarded as natural occurring fine- or coarse-grained soils or composites or mixtures of natural soils, or mixtures of natural and processed soils or aggregates such as silt, gravel, or crushed rock.

1.2 This test method applies only to soils that have 30 % or less by weight of particles retained on the ¾-inch (19.0-mm) sieve.

NOTE 3—For relationships between unit weights and water contents of soils with 30 % or less by weight of material retained on the ¾-in. (19.0-mm) sieve to unit weights and water contents of the fraction passing ¾-in. (19.0-mm) sieve, see Practice D 4718.

1.3 Three alternative procedures are provided. The procedure used shall be as indicated in the specification for the material being tested. If no procedure is specified, the choice should be based on the material gradation.

1.3.1 *Procedure A*:

1.3.1.1 *Mold*—4-in. (101.6-mm) diameter.

1.3.1.2 *Material*—Passing No. 4 (4.75-mm) sieve.

1.3.1.3 *Layers*—Three.

1.3.1.4 *Blows per layer*—25.

1.3.1.5 *Use*—May be used if 20 % or less by weight of the material is retained on the No. 4 (4.75-mm) sieve.

1.3.1.6 *Other Use*—If this procedure is not specified, materials that meet these gradation requirements may be tested using Procedures B or C.

1.3.2 *Procedure B*:

1.3.2.1 *Mold*—4-in. (101.6-mm) diameter.

1.3.2.2 *Material*—Passing ⅜-in. (9.5-mm) sieve.

1.3.2.3 *Layers*—Three.

1.3.2.4 *Blows per layer*—25.

1.3.2.5 *Use*—Shall be used if more than 20 % by weight of the material is retained on the No. 4 (4.75-mm) sieve and 20 % or less by weight of the material is retained on the ⅜-in. (9.5-mm) sieve.

1.3.2.6 *Other Use*—If this procedure is not specified, materials that meet these gradation requirements may be tested using Procedure C.

1.3.3 *Procedure C*:

1.3.3.1 *Mold*—6-in. (152.4-mm) diameter.

1.3.3.2 *Material*—Passing ¾-inch (19.0-mm) sieve.

1.3.3.3 *Layers*—Three.

1.3.3.4 *Blows per layer*—56.

1.3.3.5 *Use*—Shall be used if more than 20 % by weight of the material is retained on the ⅜-in. (9.5-mm) sieve and less than 30 % by weight of the material is retained on the ¾-in. (19.0-mm) sieve.

1.3.4 The 6-in. (152.4-mm) diameter mold shall not be used with Procedure A or B.

NOTE 4—Results have been found to vary slightly when a material is tested at the same compactive effort in different size molds.

1.4 If the test specimen contains more than 5 % by weight oversize fraction (coarse fraction) and the material will not be included in the test, corrections must be made to the unit weight and water content of the specimen or to the appropriate field in place density test specimen using Practice D 4718.

1.5 This test method will generally produce a well defined maximum dry unit weight for non-free draining soils. If this test method is used for free draining soils the maximum unit weight may not be well defined, and can be less than obtained using Test Methods D 4253.

1.6 The values in inch-pound units are to be regarded as the standard. The values stated in SI units are provided for information only.

1.6.1 In the engineering profession it is customary practice to use, interchangeably, units representing both mass and force, unless dynamic calculations ($F = Ma$) are involved. This implicitly combines two separate systems of units, that is, the absolute system and the gravimetric system. It is scientifically

[1] This test method is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.03 on Texture, Plasticity and Density Characteristics of Soils.

Current edition approved Nov. 19, 1991. Published January 1992.

undesirable to combine the use of two separate systems within a single standard. This test method has been written using inch-pound units (gravimetric system) where the pound (lbf) represents a unit of force. The use of mass (lbm) is for convenience of units and is not intended to convey the use is scientifically correct. Conversions are given in the SI system in accordance with Practice E 380. The use of balances or scales recording pounds of mass (lbm), or the recording of density in lbm/ft^3 should not be regarded as nonconformance with this standard.

1.7 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

C 127 Test Method for Specific Gravity and Absorption of Coarse Aggregate[2]

C 136 Method for Sieve Analysis of Fine and Coarse Aggregate[2]

D 422 Test Method for Particle Size Analysis of Soils[3]

D 653 Terminology Relating to Soil, Rock, and Contained Fluids[3]

D 854 Test Method for Specific Gravity of Soils[3]

D 1557 Test Methods for Moisture-Density Relations of Soils and Soil Aggregate Mixtures Using 10-lb (4.54-kg.) Rammer and 18-in. (457 mm) Drop[3]

D 2168 Test Methods for Calibration of Laboratory Mechanical-Rammer Soil Compactors[3]

D 2216 Test Method for Laboratory Determination of Water (Moisture) Content of Soil, Rock and Soil-Aggregate Mixtures[3]

D 2487 Test Method for Classification of Soils for Engineering Purposes[3]

D 2488 Practice for Description of Soils (Visual-Manual Procedure)[3]

D 4220 Practices for Preserving and Transporting Soil Samples[3]

D 4253 Test Methods for Maximum Index Density of Soils Using a Vibratory Table[3]

D 4718 Practice for Correction of Unit Weight and Water Content for Soils Containing Oversize Particles[3]

D 4753 Specification for Evaluating, Selecting and Specifying Balances and Scales For Use in Soil and Rock Testing[3]

E 1 Specification for ASTM Thermometers[4]

E 11 Specification for Wire-Cloth Sieves for Testing Purposes[5]

E 319 Practice for the Evaluation of Single-Pan Mechanical Balances[5]

E 380 Practice for Use of the International System of Units (SI) (the Modernized Metric System)[5]

[2] *Annual Book of ASTM Standards*, Vol 04.02.
[3] *Annual Book of ASTM Standards*, Vol 04.08.
[4] *Annual Book of ASTM Standards*, Vol 14.03.
[5] *Annual Book of ASTM Standards*, Vol 14.02.

3. Terminology

3.1 *Definitions:* See Terminology D 653 for general definitions.

3.2 *Description of Terms Specific to This Standard:*

3.2.1 *oversize fraction (coarse fraction), P_c* in %—portion of total sample not used in performing the compaction test; it may be the portion of total sample retained on the No. 4 (4.75-mm), ⅜-in. (9.5-mm), or ¾-in. (19.0-mm) sieve.

3.2.2 *standard effort*—the term for the 12,400 ft-lbf/ft^3(600 kN-m/m^3) compactive effort applied by the equipment and procedures of this test.

3.2.3 *standard maximum dry unit weight, γ_{dmax}* in lbf/ft^3 (kN/m^3)—the maximum value defined by the compaction curve for a compaction test using standard effort.

3.2.4 *standard optimum water content, w_o* in %—the water content at which a soil can be compacted to the maximum dry unit weight using standard compactive effort.

3.2.5 *test fraction (finer fraction), P_F* in %—the portion of the total sample used in performing the compaction test; it i the fraction passing the No. 4 (4.75-mm) sieve in Procedure A minus ⅜-in. (9.5-mm) sieve in Procedure B, or minus ¾-in. (19.0-mm) sieve in Procedure C.

4. Summary of Test Method

4.1 A soil at a selected water content is placed in three layers into a mold of given dimensions, with each layer compacted by 25 or 56 blows of a 5.5-lbf (24.4-N) rammer dropped from a distance of 12-in. (305-mm), subjecting the soil to a total compactive effort of about 12,400 ft-lbf/ft^3 (600 kN-m/m^3). The resulting dry unit weight is determin[illegible] procedure is repeated for a sufficient number of water [illegible] to establish a relationship between the dry unit weight and the water content for the soil. This data, when plotted, represents curvilinear relationship known as the compaction curve. Th values of optimum water content and standard maximum dry unit weight are determined from the compaction curve.

5. Significance and Use

5.1 Soil placed as engineering fill (embankments, foundation pads, road bases) is compacted to a dense state to obtain satisfactory engineering properties such as, shear streng[illegible] compressibility, or permeability. Also, foundation soils [illegible] often compacted to improve their engineering properties. Laboratory compaction tests provide the basis for determini[illegible] the percent compaction and water content needed to achie[illegible] the required engineering properties, and for controlling construction to assure that the required compaction and water contents are achieved.

5.2 During design of an engineered fill, shear, consolidati[illegible], permeability, or other tests require preparation of test specimens by compacting at some water content to some u[illegible]t weight. It is common practice to first determine the optim[illegible] water content (w_o) and maximum dry unit weight (γ_{dmax}) by means of a compaction test. Test specimens are compacted at a selected water content (w), either wet or dry of optimum ([illegible]) or at optimum (w_o), and at a selected dry unit weight [illegible] a percentage of maximum dry unit weight (γ_{dm}[illegible] [illegible]he selection of water content (w), either wet or dry of optim[illegible] (w_o) or at optimum (w_o) [illegible] based on past experience, or a range of values may be investigated to determine the necessary percent of compaction.

6. Apparatus

6.1 *Mold Assembly*—The molds shall be cylindrical in shape, made of rigid metal and be within the capacity and dimensions indicated in 6.1.1 or 6.1.2 and Fig. 1 and Fig. 2. The walls of the mold may be solid, split, or tapered. The "split" type may consist of two half-round sections, or a section of pipe split along one element, which can be securely locked together to form a cylinder meeting the requirements of this section. The "tapered" type shall an internal diameter taper that is uniform and not more than 0.200 in./ft (16.7- mm/m) of mold height. Each mold shall have a base plate and an extension collar assembly, both made of rigid metal and constructed so they can be securely attached and easily detached from the mold. The extension collar assembly shall have a height extending above the top of the mold of at least 2.0 in. (50.8-mm) which may include an upper section that flares out to form a funnel provided there is at least a 0.75 in. (19.0-mm) straight cylindrical section beneath it. The extension collar shall align with the inside of the mold. The bottom of the base plate and bottom of the centrally recessed area that accepts the cylindrical mold shall be planar.

6.1.1 *Mold, 4 in.*—A mold having a 4.000 ± 0.016-in. (101.6 ± 0.4-mm) average inside diameter, a height of 4.584 ± 0.018-in. (116.4 ± 0.5-mm) and a volume of 0.0333 ± 0.0005 ft^3 (944 ± 14 cm^3). A mold assembly having the minimum required features is shown in Fig. 1.

6.1.2 *Mold, 6 in.*—A mold having a 6.000 ± 0.026-in. (152.4 ± 0.7-mm) average inside diameter, a height of 4.584 ± 0.018-in. (116.4 ± 0.5-mm), and a volume of 0.075 ± 0.0009 ft^3 (2124 ± 25 cm^3). A mold assembly having the minimum required features is shown in Fig. 2.

6.2 *Rammer*—A rammer, either manually operated as described further in 6.2.1 or mechanically operated as described in 6.2.2. The rammer shall fall freely through a distance of 12 ± 0.05-in. (304.8 ± 1.3-mm) from the surface of the specimen. The mass of the rammer shall be 5.5 ± 0.02-lbm (2.5 ± 0.01-kg), except that the mass of the mechanical rammers may be adjusted as described in Test Methods D 2168, see Note 5. The striking face of the rammer shall be planar and circular, except as noted in 6.2.2.1, with a diameter when new of 2.000 ± 0.005-in. (50.80 ± 0.13-mm). The rammer shall be replaced

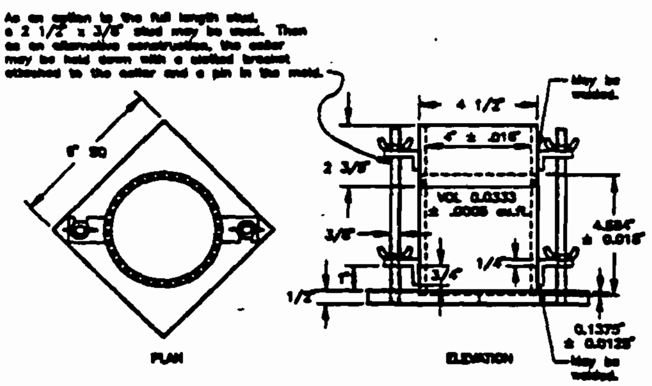


FIG. 1 4.0-in. Cylindrical Mold

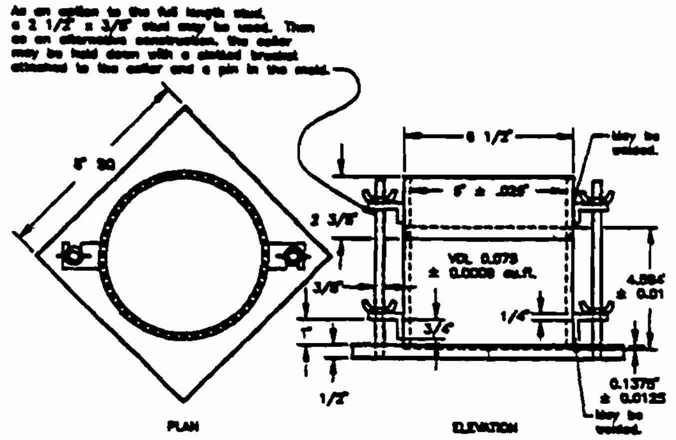


FIG. 2 6.0-in. Cylindrical Mold

if the striking face becomes worn or bellied to the extent that the diameter exceeds 2.000 ± 0.01-in. (50.80 ± 0.25-mm).

NOTE 5—It is a common and acceptable practice in the inch-pound system to assume that the mass of the rammer is equal to its mass determined using either a kilogram or pound balance and 1 lbf is equal to 1 lbm or 0.4536 kg. or 1 N is equal to 0.2248 lbm or 0.1020 kg.

6.2.1 *Manual Rammer*—The rammer shall be equipped with a guide sleeve that has sufficient clearance that the free fall of the rammer shaft and head is not restricted. The guide sleeve shall have at least four vent holes at each end (eight holes total) located with centers ¾ ± 1⁄16-in. (19.0 ± 1.6-mm) from each end and spaced 90 degrees apart. The minimum diameter of the vent holes shall be ⅜-in. (9.5-mm). Additional holes or slots may be incorporated in the guide sleeve.

6.2.2 *Mechanical Rammer-Circular Face*—The rammer shall operate mechanically in such a manner as to provide uniform and complete coverage of the specimen surface. There shall be 0.10 ± 0.03-in. (2.5 ± 0.8-mm) clearance between the rammer and the inside surface of the mold at its smallest diameter. The mechanical rammer shall meet the calibration requirements of Test Methods D 2168. The mechanical rammer shall be equipped with a positive mechanical means to support the rammer when not in operation.

6.2.2.1 *Mechanical Rammer-Sector Face*—When used with the 6-in. (152.4-mm) mold, a sector face rammer may be used in place of the circular face rammer. The specimen contact face shall have the shape of a sector of a circle of radius equal to 2.90 ± 0.02-in. (73.7 ± 0.5-mm). The rammer shall operate in such a manner that the vertex of the sector is positioned at the center of the specimen.

6.3 *Sample Extruder (optional)*—A jack, frame or other device adapted for the purpose of extruding compacted specimens from the mold.

6.4 *Balance*—A class GP5 balance meeting the requirements of Specification D 4753 for a balance of 1-g readability.

6.5 *Drying Oven*—Thermostatically controlled, preferably of a forced-draft type and capable of maintaining a uniform temperature of 230 ± 9°F (110 ± 5°C) throughout the drying chamber.

6.6 *Straightedge*—A stiff metal straightedge of any convenient length but not less than 10-in. (254-mm). The total length of the straightedge shall be machined straight to a tolerance of

±0.005-in. (±0.1-mm). The scraping edge shall be beveled if it is thicker than ⅛-in. (3-mm).

6.7 *Sieves*—¾-in. (19.0-mm), ⅜-in. (9.5-mm), and No. 4 (4.75-mm), conforming to the requirements of Specification E 11.

6.8 *Mixing Tools*—Miscellaneous tools such as mixing pan, spoon, trowel, spatula, etc., or a suitable mechanical device for thoroughly mixing the sample of soil with increments of water.

7. Calibration

7.1 Perform calibrations before initial use, after repairs or other occurrences that might affect the test results, at intervals not exceeding 1,000 test specimens, or annually, whichever occurs first, for the following apparatus:

7.1.1 *Balance*—Evaluate in accordance with Specification D 4753.

7.1.2 *Molds*—Determine the volume as described in Annex A1.

7.1.3 *Manual Rammer*—Verify the free fall distance, rammer mass, and rammer face in accordance with Section 6.2. Verify the guide sleeve requirements in accordance with Section 6.2.1.

7.1.4 *Mechanical Rammer*—Calibrate and adjust the mechanical rammer in accordance with Test Methods D 2168. In addition, the clearance between the rammer and the inside surface of the mold shall be verified in accordance with 6.2.2.

8. Test Sample

8.1 The required sample mass for Procedures A and B is approximately 35-lbm (16-kg), and for Procedure C is approximately 65-lbm (29-kg) of dry soil. Therefore, the field sample should have a moist mass of at least 50-lbm (23-kg) and 100-lbm (45-kg), respectively.

8.2 Determine the percentage of material retained on the No. 4 (4.75-mm), ⅜-in. (9.5-mm), or ¾-in. (19.0-mm) sieve as appropriate for choosing Procedure A, B, or C. Make this determination by separating out a representative portion from the total sample and determining the percentages passing the sieves of interest by Test Methods D 422 or Method C 136. It is only necessary to calculate percentages for the sieve or sieves for which information is desired.

9. Preparation of Apparatus

9.1 Select the proper compaction mold in accordance with the procedure (A, B, or C) being used. Determine and record its mass to the nearest gram. Assemble the mold, base and extension collar. Check the alignment of the inner wall of the mold and mold extension collar. Adjust if necessary.

9.2 Check that the rammer assembly is in good working condition and that parts are not loose or worn. Make any necessary adjustments or repairs. If adjustments or repairs are made, the rammer must be recalibrated.

10. Procedure

10.1 *Soils*:

10.1.1 Do not reuse soil that has been previously laboratory compacted.

10.1.2 When using this test method for soils containing hydrated halloysite, or where past experience with a particular soil indicates that results will be altered by air drying, use the moist preparation method (see 10.2).

10.1.3 Prepare the soil specimens for testing in accordance with 10.2 (preferred) or with 10.3.

10.2 *Moist Preparation Method (preferred)*—Withou viously drying the sample, pass it through a No. 4 (4.75-mm), ⅜-in. (9.5-mm), or ¾-in. (19.0-mm) sieve, depending on the procedure (A, B, or C) being used. Determine the water content of the processed soil.

10.2.1 Prepare at least four (preferably five) specimens having water contents such that they bracket the estimated optimum water content. A specimen having a water content close to optimum should be prepared first by trial additions of water and mixing (see Note 6). Select water contents for the rest of the specimens to provide at least two specimens wet and two specimens dry of optimum, and water contents varying by about 2 %. At least two water contents are necessary on the wet and dry side of optimum to accurately define the dry unit weight compaction curve (see 10.5). Some soils with very high optimum water content or a relatively flat compaction curve may require larger water content increments to obtain a well defined maximum dry unit weight. Water content increments should not exceed 4 %.

NOTE 6—With practice it is usually possible to visually judge a point near optimum water content. Typically, soil at optimum water content can be squeezed into a lump that sticks together when hand pressure is released, but will break cleanly into two sections when "bent". At water contents dry of optimum soils tend to crumble; wet of optimum soils tend to stick together in a sticky cohesive mass. Optimum water content is typically slightly less than the plastic limit.

10.2.2 Use approximately 5-lbm (2.3-kg) of the siev for each specimen to be compacted using Procedure A o r 13-lbm (5.9-kg) using Procedure C. To obtain the specimen water contents selected in 10.2.1, add or remove the require amounts of water as follows: to add water, spray it into the soi during mixing; to remove water, allow the soil to dry in air at ambient temperature or in a drying apparatus such that th temperature of the sample does not exceed 140°F (60°C). Mi the soil frequently during drying to maintain an even water content distribution. Thoroughly mix each specimen to ensure even distribution of water throughout and then place in separate covered container and allow to stand in accordanc with Table 1 prior to compaction. For the purpose of selecting a standing time, the soil may be classified using Test Metho D 2487, Practice D 2488 or data on other samples from th same material source. For referee testing, classification shall be by Test Method D 2487.

10.3 *Dry Preparation Method*—If the sample is too damp be friable, reduce the water content by air drying until t material is friable. Drying may be in air or by the use of drying apparatus such that the temperature of the sample does n exceed 140°F (60°C). Thoroughly break up the aggregations such a manner as to avoid breaking individual particles. Pass

TABLE 1 Required Standing Times of Moisturized Specimens

Classification	Minimum Standing Tim
GW, GP, SW, SP	No Requirement
GM, SM	3
All other soils	16

TABLE 2 Metric Equivalents for Figs. 1 and 2

in.	mm
0.016	0.41
0.026	0.66
0.032	0.81
0.028	0.71
½	12.70
2½	63.50
2⅝	66.70
4	101.60
4½	114.30
4.584	116.43
4¾	120.60
6	152.40
6½	165.10
6⅝	168.30
6¾	171.40
8¼	209.60
ft^3	cm^3
1/30 (0.0333)	943
0.0005	14
(0.0750)	2,124
0.0011	31

the material through the appropriate sieve: No. 4 (4.75-mm), ⅜-in. (9.5-mm), or ¾-in. (19.0-mm). When preparing the material by passing over the ¾-in. sieve for compaction in the 6-in. mold, break up aggregations sufficiently to at least pass the ⅜-in. sieve in order to facilitate the distribution of water throughout the soil in later mixing.

10.3.1 Prepare at least four (preferably five) specimens in accordance with 10.2.1.

10.3.2 Use approximately 5-lbm (2.3-kg) of the sieved soil for each specimen to be compacted using Procedure A or B, or 13-lbm (5.9-kg) using Procedure C. Add the required amounts of water to bring the water contents of the specimens to the values selected in 10.3.1. Follow the specimen preparation procedure specified in 10.2.2 for drying the soil or adding water into the soil and curing each test specimen.

10.4 *Compaction*—After curing, if required, each specimen shall be compacted as follows:

10.4.1 Determine and record the mass of the mold or mold and base plate.

10.4.2 Assemble and secure the mold and collar to the base plate. The mold shall rest on a uniform rigid foundation, such as provided by a cylinder or cube of concrete with a mass of not less than 200-lbm (91-kg). Secure the base plate to the rigid foundation. The method of attachment to the rigid foundation shall allow easy removal of the assembled mold, collar and base plate after compaction is completed.

10.4.3 Compact the specimen in three layers. After compaction, each layer should be approximately equal in thickness. Prior to compaction, place the loose soil into the mold and spread into a layer of uniform thickness. Lightly tamp the soil prior to compaction until it is not in a fluffy or loose state, using either the manual compaction rammer or a 2-in. (5-mm) diameter cylinder. Following compaction of each of the first two layers, any soil adjacent to the mold walls that has not been compacted or extends above the compacted surface shall be trimmed. The trimmed soil may be included with the additional soil for the next layer. A knife or other suitable device may be used. The total amount of soil used shall be such that the third compacted layer slighly extends into the collar, but does not exceed ¼-in. (6-mm) above the top of the mold. If the third layer does extend above the top of the mold by more than ¼-in. (6-mm), the specimen shall be discarded. The specimen shall be discarded when the last blow on the rammer for the third layer results in the bottom of the rammer extending below the top of the compaction mold.

10.4.4 Compact each layer with 25 blows for the 4-in. (101.6-mm) mold or with 56 blows for the 6-in. (152.4-mm) mold.

NOTE 7—When compacting specimens wetter than optimum water content, uneven compacted surfaces can occur and operator judgement is required as to the average height of the specimen.

10.4.5 In operating the manual rammer, take care to avoid lifting the guide sleeve during the rammer upstroke. Hold the guide sleeve steady and within 5° of vertical. Apply the blows at a uniform rate of approximately 25 blows/min and in such a manner as to provide complete, uniform coverage of the specimen surface.

10.4.6 Following compaction of the last layer, remove the collar and base plate from the mold, except as noted in 10.4.7. A knife may be used to trim the soil adjacent to the collar to loosen the soil from the collar before removal to avoid disrupting the soil below the top of the mold.

10.4.7 Carefully trim the compacted specimen even with the top of the mold by means of the straightedge scraped across the top of the mold to form a plane surface even with the top of the mold. Initial trimming of the specimen above the top of the mold with a knife may prevent the soil from tearing below the top of the mold. Fill any holes in the top surface with unused or trimmed soil from the specimen, press in with the fingers, and again scrape the straightedge across the top of the mold. Repeat the appropriate preceding operations on the bottom of the specimen when the mold volume was determined without the base plate. For very wet or dry soils, soil or water may be lost if the base plate is removed. For these situations, leave the base plate attached to the mold. When the base plate is left attached, the volume of the mold must be calibrated with the base plate attached to the mold rather than a plastic or glass plate as noted in Annex A1, A1.4.

10.4.8 Determine and record the mass of the specimen and mold to the nearest gram. When the base plate is left attached, determine and record the mass of the specimen, mold and base plate to the nearest gram.

10.4.9 Remove the material from the mold. Obtain a specimen for water content by using either the whole specimen (preferred method) or a representative portion. When the entire specimen is used, break it up to facilitate drying. Otherwise, obtain a portion by slicing the compacted specimen axially through the center and removing about 500-g of material from the cut faces. Obtain the water content in accordance with Test Method D 2216.

10.5 Following compaction of the last specimen, compare the wet unit weights to ensure that a desired pattern of obtaining data on each side of the optimum water content will be attained for the dry unit weight compaction curve. Plotting the wet unit weight and water content of each compacted specimen can be an aid in making the above evaluation. If the desired pattern is not obtained, additional compacted specimens will be required. Generally, one water content value wet of the water content defining the maximum wet unit weight is sufficient to ensure data on the wet side of optimum water content for the maximum dry unit weight.

11. Calculation

11.1 Calculate the dry unit weight and water content of each compacted specimen as explained in 11.3 and 11.4. Plot the values and draw the compaction curve as a smooth curve through the points (see example, Fig. 3). Plot dry unit weight to the nearest 0.1 lbf/ft^3 (0.2 kN/m^3) and water content to the nearest 0.1 %. From the compaction curve, determine the optimum water content and maximum dry unit weight. If more than 5 % by weight of oversize material was removed from the sample, calculate the corrected optimum water content and maximum dry unit weight of the total material using Practice D 4718. This correction may be made to the appropriate field in place density test specimen rather than to the laboratory test specimen.

11.2 Plot the 100 % saturation curve. Values of water content for the condition of 100 % saturation can be calculated as explained in 11.5 (see example, Fig. 3).

NOTE 8—The 100 % saturation curve is an aid in drawing the compaction curve. For soils containing more than approximately 10 % fines at water contents well above optimum, the two curves generally become roughly parallel with the wet side of the compaction curve between 92 % to 95 % saturation. Theoretically, the compaction curve cannot plot to the right of the 100 % saturation curve. If it does, there is an error in specific gravity, in measurements, in calculations, in test procedures, or in plotting.

NOTE 9—The 100 % saturation curve is sometimes referred to as the zero air voids curve or the complete saturation curve.

11.3 *Water Content, w*—Calculate in accordance with Test Method D 2216.

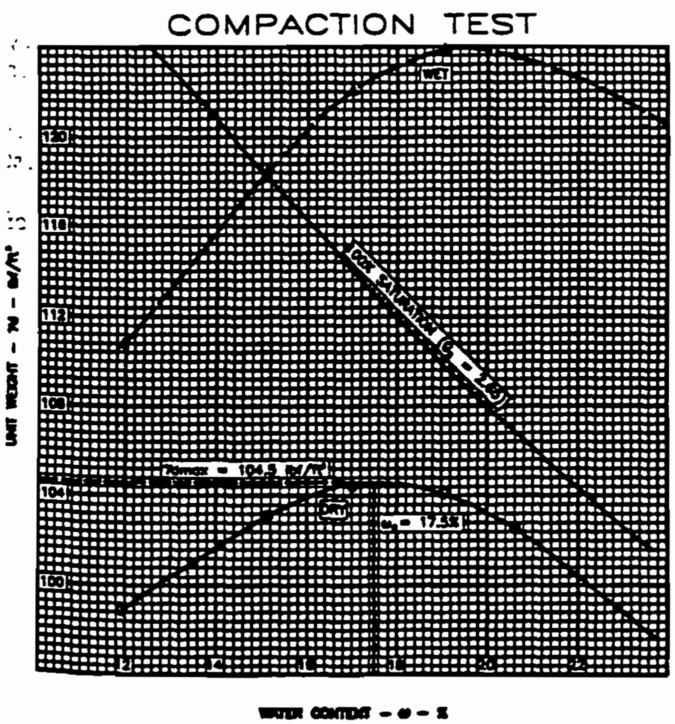


FIG. 3 Example Compaction Curve Plotting

11.4 *Dry Unit Weights*—Calculate the moist density (Eq 1), the dry density (Eq 2), and then the dry unit weight (Eq 3) as follows:

$$\rho_m = \frac{(M_t - M_{md})}{1000\,V}$$

where:

ρ_m = moist density of compacted specimen, Mg/m^3,
M_t = mass of moist specimen and mold, kg,
M_{md} = mass of compaction mold, kg, and
V = volume of compaction mold, m^3(see Annex A1)

$$\rho_d = \rho_m/(1 + w/100) \quad (2)$$

where:

ρ_d = dry density of compacted specimen, Mg/m^3, and
w = water content,% .

$$\gamma_d = 62.43\ \rho_d \text{ in lbf/ft}^3 \quad (3)$$

or

$$\gamma_d = 9.807\ \rho_d \text{ in kN/m}^3 \quad (4)$$

where:

γ_d = dry unit weight of compacted specimen.

11.5 To calculate points for plotting the 100 % saturation curve or zero air voids curve select values of dry unit weight, calculate corresponding values of water content corresponding to the condition of 100 % saturation as follows:

$$w_{sat} = \frac{(\gamma_w)(G_s) - \gamma_d}{(\gamma_d)(G_s)} \times 100 \quad (5)$$

where:

w_{sat} = water content for complete saturation, %,
γ_w = unit weight of water, 62.43 lbf/ft^3 (9.807 kn/m
γ_d = dry unit weight of soil, and
G_s = specific gravity of soil.

NOTE 10—Specific gravity may be estimated for the test specimen on the basis of test data from other samples of the same soil classification and source. Otherwise, a specific gravity test (Test Method C 127, Test Method D 854, or both) is necessary.

12. Report

12.1 The report shall contain the following information:

12.1.1 Procedure used (A, B, or C).

12.1.2 Preparation method used (moist or dry).

12.1.3 As received water content if determined.

12.1.4 Standard optimum water content, to the nearest 0.5 %.

12.1.5 Standard maximum dry unit weight, to the nearest 0.5 lbf/ft^3.

12.1.6 Description of rammer (manual or mechanical).

12.1.7 Soil sieve data when applicable for determination of procedure (A, B, or C) used.

12.1.8 Description of material used in test, by Practice D 2488, or classification by Test Method D 2487.

12.1.9 Specific gravity and method of determination.

12.1.10 Origin of material used in test, for example, location, depth, and the like.

12.1.11 Compaction curve plot showing compaction points used to establish compaction curve, and 100 % saturation curve, point of maximum dry unit weight and optimum water content.

12.1.12 Oversize correction data if used, including the oversize fraction (coarse fraction), P_c in %.

13. Precision and Bias

13.1 *Precision*—Data are being evaluated to determine the precision of this test method. In addition, pertinent data is being solicited from users of the test method.

13.2 *Bias*—It is not possible to obtain information on bias because there is no other method of determining the values of standard maximum dry unit weight and optimum water content.

14. Keywords

14.1 NT—impact compaction using standard effort; RT—density; RT—moisture-density curves; RT—proctor test; UF—compaction characteristics; UF—soil compaction; USE—laboratory tests

ANNEX

(Mandatory Information)

A1. VOLUME OF COMPACTION MOLD

A1.1 Scope

A1.1.1 This annex describes the procedure for determining the volume of a compaction mold.

A1.1.2 The volume is determined by a water-filled method and checked by a linear-measurement method.

A1.2 Apparatus

A1.2.1 In addition to the apparatus listed in Section 6 the following items are required:

A1.2.1.1 *Vernier or Dial Caliper*—having a measuring range of at least 0 to 6 in. (0 to 150 mm) and readable to at least 0.001 in. (0.02 mm).

A1.2.1.2 *Inside Micrometer*—having a measuring range of at least 2 to 12 in. (50 to 300 mm) and readable to at least 0.001 in. (0.02 mm).

A1.2.1.3 *Plastic or Glass Plates*—Two plastic or glass plates approximately 8 in. square by ¼ in. thick (200 by 200 mm by 6 mm).

A1.2.1.4 *Thermometer*—0 to 50°C range, 0.5°C graduations, conforming to the requirements of Specification E 1.

A1.2.1.5 *Stopcock grease* or similar sealant.

A1.2.1.6 *Miscellaneous equipment*—Bulb syringe, towels, etc.

A1.3 Precautions

A1.3.1 Perform this procedure in an area isolated from drafts or extreme temperature fluctuations.

A1.4 Procedure

A1.4.1 *Water-Filling Method*:

A1.4.1.1 Lightly grease the bottom of the compaction mold and place it on one of the plastic or glass plates. Lightly grease the top of the mold. Be careful not to get grease on the inside of the mold. If it is necessary to use the base plate, as noted in 10.4.7, place the greased mold onto the base plate and secure with the locking studs.

A1.4.1.2 Determine the mass of the greased mold and both plastic or glass plates to the nearest 0.01-lbm (1-g) and record. When the base plate is being used in lieu of the bottom plastic or glass plate determine the mass of the mold, base plate and a single plastic or glass plate to be used on top of the mold to the nearest 0.01-lbm (1-g) and record.

A1.4.1.3 Place the mold and the bottom plastic or glass plate on a firm, level surface and fill the mold with water to slightly above its rim.

A1.4.1.4 Slide the second plate over the top surface of the mold so that the mold remains completely filled with water and air bubbles are not entrapped. Add or remove water as necessary with a bulb syringe.

A1.4.1.5 Completely dry any excess water from the outside of the mold and plates.

A1.4.1.6 Determine the mass of the mold, plates and water and record to the nearest 0.01-lbm (1-g).

A1.4.1.7 Determine the temperature of the water in the mold to the nearest 1°C and record. Determine and record the absolute density of water from Table A1.1.

A1.4.1.8 Calculate the mass of water in the mold by subtracting the mass determined in A1.4.1.2 from the mass determined in A1.4.1.6.

A1.4.1.9 Calculate the volume of water by dividing the mass of water by the density of water and record to the nearest 0.0001 ft^3 (1 cm^3).

A1.4.1.10 When the base plate is used for the calibration of the mold volume repeat A1.4.1.3-A1.4.1.9.

A1.4.2 *Linear Measurement Method*:

A1.4.2.1 Using either the vernier caliper or the inside micrometer, measure the diameter of the mold 6 times at the

TABLE A1.1 Density of Water[A]

Temperature, °C (°F)	Density of Water, g/ml
18 (64.4)	0.99862
19 (66.2)	0.99843
20 (68.0)	0.99823
21 (69.8)	0.99802
22 (71.6)	0.99779
23 (73.4)	0.99756
24 (75.2)	0.99733
25 (77.0)	0.99707
26 (78.8)	0.99681

[A]Values other than shown may be obtained by referring to the Handbook of Chemistry and Physics, Chemical Rubber Publishing Co., Cleveland, Ohio.

top of the mold and 6 times at the bottom of the mold, spacing each of the six top and bottom measurements equally around the circumference of the mold. Record the values to the nearest 0.001-in. (0.02-mm).

A1.4.2.2 Using the vernier caliper, measure the inside height of the mold by making three measurements equally spaced around the circumference of the mold. Record values to the nearest 0.001-in. (0.02-mm).

A1.4.2.3 Calculate the average top diameter, average bottom diameter and average height.

A1.4.2.4 Calculate the volume of the mold and record to the nearest 0.0001 ft^3 (1 cm^3) as follows:

$$V = \frac{(\pi)(h)(d_t + d_b)^2}{(16)(1728)} \text{ (inch-pound)} \qquad \text{(A1.1)}$$

$$V = \frac{(\pi)(h)(d_t + d_b)^2}{(16)(10^3)} (SI) \qquad \text{(A1.2)}$$

where:

V = volume of mold, ft^3 (cm^3),
h = average height, in. (mm),
d_t = average top diameter, in. (mm),
d_b = average bottom diameter, in. (mm),
$1/1728$ = constant to convert in^3 to ft^3, and
$1/10^3$ = constant to convert mm^3 to cm^3.

A1.5 Comparison of Results

A1.5.1 The volume obtained by either method should be within the volume tolerance requirements of 6.1.1 and 6.1.2.

A1.5.2 The difference between the two methods should not exceed 0.5 % of the nominal volume of the mold.

A1.5.3 Repeat the determination of volume if these criteria are not met.

A1.5.4 Failure to obtain satisfactory agreement between the two methods, even after several trials, is an indication that the mold is badly deformed and should be replaced.

A1.5.5 Use the volume of the mold determined using the water-filling method as the assigned volume value for calculating the moist and dry density (see 11.4).

Standard Test Method for CBR (California Bearing Ratio) of Laboratory-Compacted Soils[1]

This standard is issued under the fixed designation D 1883; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope *

1.1 This test method covers the determination of the CBR (California Bearing Ratio) of pavement subgrade, subbase, and base/course materials from laboratory compacted specimens. The test method is primarily intended for but not limited to, evaluating the strength of cohesive materials having maximum particle sizes less than ¾ in. (19 mm).

NOTE 1—The agency performing this test can be evaluated in accordance with Practice D 3740.

Not withstanding statements on precision and bias contained in this Standard: The precision of this test method is dependent on the competence of the personnel performing it and the suitability of the equipment and facilities used. Agencies which meet the criteria of Practice D 3740 are generally considered capable of competent and objective testing. Users of this method are cautioned that compliance with Practice D 3740 does not in itself assure reliable testing. Reliable testing depends on many factors; Practice D 3740 provides a means of evaluating some of those factors.

1.2 When materials having maximum particle sizes greater than ¾ in. (19 mm) are to be tested, this test method provides for modifying the gradation of the material so that the material used for tests all passes the ¾-in. sieve while the total gravel (+No. 4 to 3 in.) fraction remains the same. While traditionally this method of specimen preparation has been used to avoid the error inherent in testing materials containing large particles in the CBR test apparatus, the modified material may have significantly different strength properties than the original material. However, a large experience base has developed using this test method for materials for which the gradation has been modified, and satisfactory design methods are in use based on the results of tests using this procedure.

1.3 Past practice has shown that CBR results for those materials having substantial percentages of particles retained on the No. 4 sieve are more variable than for finer materials. Consequently, more trials may be required for these materials to establish a reliable CBR.

1.4 This test method provides for the determination of the CBR of a material at optimum water content or a range of water content from a specified compaction test and a specified dry unit weight. The dry unit weight is usually given as a percentage of maximum dry unit weight from the compaction tests of Test Methods D 698 or D 1557.

1.5 The agency requesting the test shall specify the water content or range of water content and the dry unit weight for which the CBR is desired.

1.6 Unless specified otherwise by the requesting agency, or unless it has been shown to have no effect on test results for the material being tested, all specimens shall be soaked prior to penetration.

1.7 For the determination of CBR of field compacted materials, see Test Method D 4429.

1.8 The values stated in inch-pound units are to be regarded as the standard. The SI equivalents shown in parentheses may be approximate.

1.9 *This standard does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

D 422 Test Method for Particle-Size Analysis of Soils[2]

D 653 Terminology Relating to Soil, Rock, and Contained Fluids[2]

D 698 Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3 (600 kN-m/m^3))[2]

D 1557 Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3 (2,700 kN-m/m^3))[2]

D 2168 Test Methods for Calibration of Laboratory Mechanical-Rammer Soil Compactors[2]

D 2216 Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock[2]

D 2487 Classification of Soils for Engineering Purposes (Unified Soil Classification System)[2]

D 2488 Practice for Description and Identification of Soils (Visual-Manual Procedure)[2]

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[1] This test method is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.08 on Special and Construction Control Tests.

Current edition approved Feb. 10, 1999. Published May 1999. Originally published as D 1883 – 61T. Last previous edition D 1883 – 94.

[2] *Annual Book of ASTM Standards*, Vol 04.08.

*A Summary of Changes section appears at the end of this standard.

D 3740 Practice for Minimum Requirements of Agencies Engaged in the Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction[2]

D 4318 Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils[2]

D 4429 Test Method for CBR (California Bearing Ratios) of Soils in Place[2]

3. Summary of Test Method

3.1 For tests performed on materials compacted to one water content, three specimens are prepared. The specimens are compacted using three different compactive efforts to obtain unit weights both above and below the desired unit weight. After allowing specimens to take on water by soaking, or other specified treatment such as curing, each specimen is subjected to penetration by a cylindrical rod. Results of stress (load) versus penetration depth are plotted to determine the CBR for each specimen. The CBR at the specified density is determined from a graph of CBR versus dry unit weight.

3.2 For tests in which the result is to be determined for a water content range, a series of specimens at each of three compactive efforts are prepared over the range of water content of interest. The compactive efforts are chosen to produce unit weights above and below the desired unit weight. After allowing the specimens to take on water by soaking, or other specified treatment such as curing, each specimen is penetrated. Results are plotted to obtain the CBR for each specimen. A plot of CBR versus unit weight for each water content is made to determine the minimum CBR for the water content range of interest.

4. Significance and Use

4.1 This test method is used to evaluate the potential strength of subgrade, subbase, and base course material, including recycled materials for use in road and airfield pavements. The CBR value obtained in this test forms an integral part of several flexible pavement design methods.

4.2 For applications where the effect of compaction water content on CBR is small, such as cohesionless, coarse-grained materials, or where an allowance is made for the effect of differing compaction water contents in the design procedure, the CBR may be determined at the optimum water content of a specified compaction effort. The dry unit weight specified is normally the minimum percent compaction allowed by the using agency's field compaction specification.

4.3 For applications where the effect of compaction water content on CBR is unknown or where it is desired to account for its effect, the CBR is determined for a range of water content, usually the range of water content permitted for field compaction by using agency's field compaction specification.

4.4 The criteria for test specimen preparation of self cementing (and other) materials which gain strength with time must be based on a geotechnical engineering evaluation. As directed by the engineer, self cementing materials shall be properly cured until bearing ratios representing long term service conditions can be measured.

5. Apparatus

5.1 *Loading Machine*—The loading machine shall be equipped with a movable head or base that travels at a uniform (not pulsating) rate of 0.05 in. (1.27 mm)/min for use in forcing the penetration piston into the specimen. The machine shall be equipped with a load-indicating device that can be read [illegible] lbf (44 N) or less. The minimum capacity of the l[illegible] machine shall be based on the requirements indicated [illegible] 1.

5.2 *Mold*—The mold shall be a rigid metal cylinder with an inside diameter of 6 ± 0.026 in. (152.4 ± 0.66 mm) and a height of 7 ± 0.018 in. (177.8 ± 0.46 mm). It shall be provided with a metal extension collar at least 2.0 in. (50.8 mm) in height and a metal base plate having at least twenty eight 1/16-in. (1.59-mm) diameter holes uniformly spaced over the plate within the inside circumference of the mold. When assembled with spacer disc in place in the bottom of the mold, the mold shall have an internal volume (excluding extension collar) of 0.075 ± 0.0009 ft (2124 ± 25 cm). Fig. 1 shows a satisfactory mold design. A calibration procedure should be used to confirm the actual volume of the mold with the spacer disk inserted. Suitable calibrations are contained in Test Methods D 698 and D 1557.

5.3 *Spacer Disk*—A circular metal spacer disc (see Fig. 1) having a minimum outside diameter of 5 15/16 in. (150.8 mm) but no greater than will allow the spacer to easily slip into the mold. The spacer disc shall be 2.416± 0.005 in. (61.37 ± 0.127 mm) in height.

5.4 *Rammer*—A rammer as specified in either Test Methods D 698 or D 1557 except that if a mechanical rammer is used [illegible] must be equipped with a circular foot, and when so equipped, must provide a means for distributing the rammer blows uniformly over the surface of the soil when compact[illegible] 6-in. (152.4-mm) diameter mold. The mechanical ramm[illegible] be calibrated and adjusted in accordance with Test Methods D 2168.

5.5 *Expansion-Measuring Apparatus*— An adjustable me[illegible] stem and perforated metal plate, similar in configuration to that shown in Fig. 1. The perforated plate shall be 5 7/8 to 5 15/16 in. (149.23 to 150.81 mm) in diameter and have at least forty-t[illegible] 1/16-in. (1.59-mm) diameter holes uniformly spaced over [illegible] plate. A metal tripod to support the dial gage for measuring the amount of swell during soaking is also required.

5.6 *Weights*—One or two annular metal weights havin[illegible] total mass of 4.54 ± 0.02 kg and slotted metal weights each having masses of 2.27 ± 0.02 kg. The annular weight shall be 5 7/8 to 5 15/16 in. (149.23 to 150.81 mm) in diameter and sh[illegible] have a center hole of approximately 2 1/8in. (53.98 mm).

5.7 *Penetration Piston*—A metal piston 1.954 ± 0.005 in. (49.63 ± 0.13 mm) in diameter and not less than 4 in. (10[illegible] mm) long (see Fig. 1). If, from an operational standpoint, [illegible] advantageous to use a piston of greater length, the longer piston may be used.

5.8 *Gages*—Two dial gages reading to 0.001 in. (0.025 [illegible])

TABLE 1 Minimum Load Capacity

Maximum Measurable CBR	Minimum Load Capacity (lbf)	(kN)
20	2500	[illegible]
50	5000	[illegible]
>50	10 000	44[illegible]

TABLE 2 Metric Equivalents

Inch-Pound Units, in.	Metric Equivalent, mm	Inch-Pound Units, in.	Metric Equivalent, mm	Inch-Pound Units, in.	Metric Equivalent, mm
0.003	0.076	19/32	15.08	3 1/2	88.90
0.005	0.127	5/8	15.88	3 3/4	95.25
0.135	3.43	3/4	19.10	4 1/4	108.0
0.201	5.11	15/16	23.81	4 1/2	114.3
0.4375	11.11	1	25.40	4 3/4	120.7
0.4378	11.12	1 1/8	28.58	5 7/8	149.2
0.510	12.95	1 1/4	31.8	5 15/16	150.8
0.633	16.08	1 3/8	34.9	6	152.0
1.370	34.60	1 1/2	38.10	6 7/32	158.0
1.375	34.93	1 3/4	44.5	6 1/2	165.1
1.954	49.63	1 13/16	46.04	7	177.8
2.416	61.37	1 15/16	49.21	7 1/2	190.1
1/16	1.59	2	50.80	8 3/8	212.7
7/32	5.56	2 1/8	53.98	8 1/2	215.9
1/4	6.35	2 1/5	55.9	9 3/8	238.1
3/8	9.53	2 1/4	57.2	14 1/4	362.0
7/16	11.11	2 1/2	63.50	18	457.2
15/32	11.91	2 3/4	69.85	32 1/4	719.2
1/2	12.70	2 31/32	75.41	36 5/8	930.3
17/32	13.49	3	76.20	39	990.6

Inch-Pound Units, lb	Metric Equivalent, kg	Inch-Pound Units, psi	Metric Equivalent, MPa
0.04	0.02	200	1.4
0.05	0.02	400	2.8
0.12	0.05	600	4.1
0.59	0.27	800	5.5
0.71	0.32	1000	6.9
0.75	0.34	1200	8.3
3.20	1.45	1400	9.7
5.00	2.27		
10.00	4.54		

with a range of 0.200 minimum.

5.9 *Miscellaneous Apparatus*—Other general apparatus such as a mixing bowl, straightedge, scales, soaking tank or pan, oven, fast filtering high wet strength filter paper, dishes, and 2-in., ¾-in. and No. 4 sieves.

6. Sample

6.1 The sample shall be handled and specimen(s) for compaction shall be prepared in accordance with the procedures given in Test Methods D 698 or D 1557 for compaction in a 6-in. (152.4-mm) mold except as follows:

6.1.1 If all material passes a ¾-in. (19-mm) sieve, the entire gradation shall be used for preparing specimens for compaction without modification. If there is material retained on the ¾-in. (19-mm) sieve, the material retained on the ¾-in. (19-mm) sieve shall be removed and replaced by an equal amount of material passing the ¾-in. (19-mm) sieve and retained on the No. 4 sieve obtained by separation from portions of the sample not otherwise used for testing.

7. Test Specimens

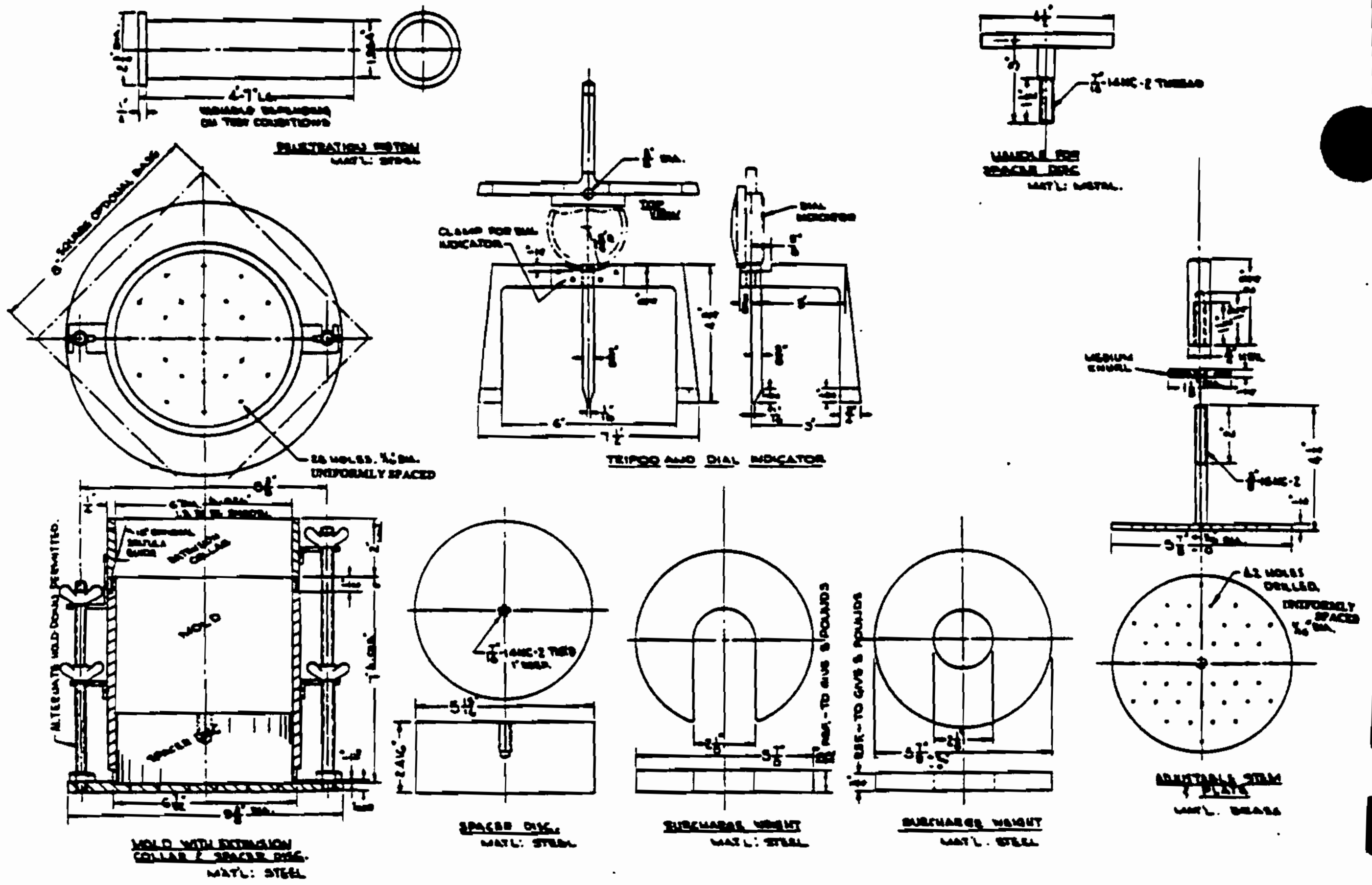
7.1 *Bearing Ratio at Optimum Water Content Only*—Using material prepared as described in 6.1, conduct a control compaction test with a sufficient number of test specimens to definitely establish the optimum water content for the soil using the compaction method specified, either Test Methods D 698 or D 1557. A previously performed compaction test on the same material may be substituted for the compaction test just described, provided that if the sample contains material retained on the ¾-in. (19-mm) sieve, soil prepared as describe in 6.1 is used (Note 1).

NOTE 2—Maximum dry unit weight obtained from a compaction te performed in a 4-in. (101.6-mm) diameter mold may be slightly great than the maximum dry unit weight obtained from compaction in the 6-i (152.4-mm) compaction mold or CBR mold.

7.1.1 For cases where the CBR is desired at 100 % max mum dry unit weight and optimum water content, compact specimen using the specified compaction procedure, either Te Methods D 698 or D 1557, from soil prepared to within ±0. percentage point of optimum water content in accordance wi Test Method D 2216.

NOTE 3—Where the maximum dry unit weight was determined fr compaction in the 4-in. (101.6-mm) mold, it may be necessary to comp specimens as described in 7.1.2, using 75 blows per layer or some ot value sufficient to produce a specimen having a density equal to or grea than that required.

7.1.2 Where the CBR is desired at optimum water conte and some percentage of maximum dry unit weight, compa three specimens from soil prepared to within ±0.5 percenta point of optimum water content and using the specifi compaction but using a different number of blows per layer f each specimen. The number of blows per layer shall be vari as necessary to prepare specimens having unit weights abo and below the desired value. Typically, if the CBR for soil 95 % of maximum dry unit is desired, specimens compact using 56, 25, and 10 blows per layer is satisfactory. Penetrati shall be performed on each of these specimens.



NOTE 1—See Table 2 for metric equivalents.

FIG. 1 Bearing Ratio Test Apparatus

7.2 *Bearing Ratio for a Range of Water Content*—Prepare specimens in a manner similar to that described in 7.1 except that each specimen used to develop the compaction curve shall be penetrated. In addition, the complete water content-unit weight relation for the 25-blow and 10-blow per layer compactions shall be developed and each test specimen compacted shall be penetrated. Perform all compaction in the CBR mold. In cases where the specified unit weight is at or near 100 % maximum dry unit weight, it will be necessary to include a compactive effort greater than 56-blows per layer (Note 3).

NOTE 4—A semilog log plot of dry unit weight versus compactive effort usually gives a straight line relation when compactive effort in ft-lb/ft^3 is plotted on the log scale. This type of plot is useful in establishing the compactive effort and number of blows per layer needed to bracket the specified dry unit weight and water content range.

7.2.1 If the sample is to be soaked, take a representative sample of the material, for the determination of moisture, at the beginning of compaction and another sample of the remaining material after compaction. Use Test Method D 2216 to determine the moisture content. If the sample is not to be soaked, take a moisture content sample in accordance with Test Methods D 698 or D 1557 if the average moisture content is desired.

7.2.2 Clamp the mold (with extension collar attached) to the base plate with the hole for the extraction handle facing down. Insert the spacer disk over the base plate and place a disk of filter paper on top of the spacer disk. Compact the soil-water mixture into the mold in accordance with 7.1, 7.1.1, or 7.1.2.

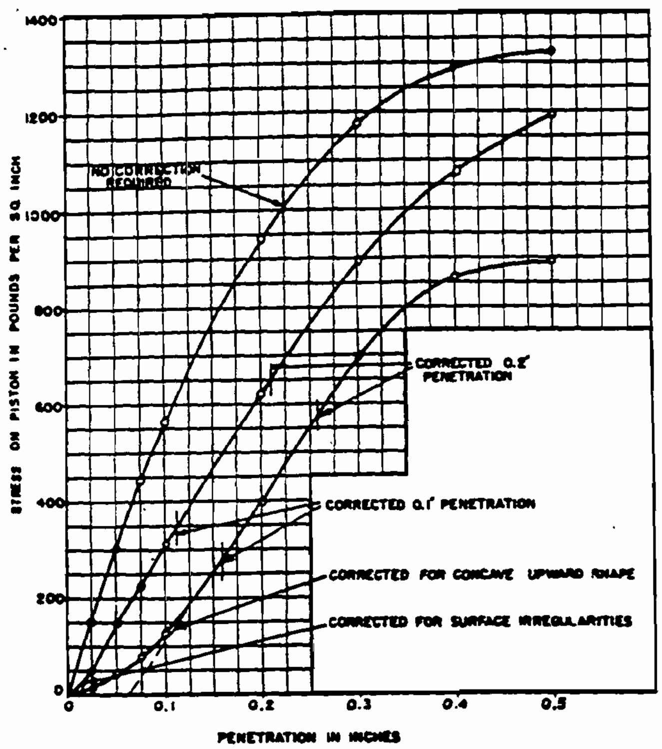
7.2.3 Remove the extension collar and carefully trim the compacted soil even with the top of the mold by means of a straightedge. Patch with smaller size material any holes that may have developed in the surface by the removal of coarse material. Remove the perforated base plate and spacer disk, weigh, and record the mass of the mold plus compacted soil. Place a disk of coarse filter paper on the perforated base plate, invert the mold and compacted soil, and clamp the perforated base plate to the mold with compacted soil in contact with the filter paper.

7.2.4 Place the surcharge weights on the perforated plate and adjustable stem assembly and carefully lower onto the compacted soil specimen in the mold. Apply a surcharge equal to the weight of the base material and pavement within 2.27 kg (5 lb), but in no case shall the total weight used be less than 4.54 kg (10 lb). If no pavement weight is specified, use 4.54 kg. Immerse the mold and weights in water allowing free access of water to the top and bottom of the specimen. Take initial measurements for swell and allow the specimen to soak for 96 h. Maintain a constant water level during this period. A shorter immersion period is permissible for fine grained soils or granular soils that take up moisture readily, if tests show the shorter period does not affect the results. At the end of 96 h, take final swell measurements and calculate the swell as percentage of the initial height of the specimen.

7.2.5 Remove the free water and allow the specimen to drain downward for 15 min. Take care not to disturb the surface of the specimen during the removal of the water. It may be necessary to tilt the specimen in order to remove the surface water. Remove the weights, perforated plate, and filter paper, and determine and record the mass.

8. Procedure for Bearing Test

8.1 Place a surcharge of weights on the specimen sufficient to produce an intensity of loading equal to the weight of the base material. If no pavement weight is specified, use 4.54 kg mass. If the specimen has been soaked previously, the surcharge shall be equal to that used during the soaking period. To prevent upheaval of soil into the hole of the surcharge weights, place the 2.27 kg annular weight on the soil surface prior to seating the penetration piston, after which place the remainder of the surcharge weights.



NOTE 1—See Table 2 for metric equivalents.

FIG. 2 Correction of Load-Penetration Curves

8.2 Seat the penetration piston with the smallest possible load, but in no case in excess of 10 lbf (44 N). Set both the stress and penetration gages to zero. This initial load is required to ensure satisfactory seating of the piston and shall be considered as the zero load when determining the load penetration relation. Anchor the strain gage to the load measuring device, if possible; in no case attach it to the testing machines support bars (legs).

NOTE 5—At high loads the supports may torque and affect the reading of the penetration gage. Checking the depth of piston penetration is one means of checking for erroneous strain indications.

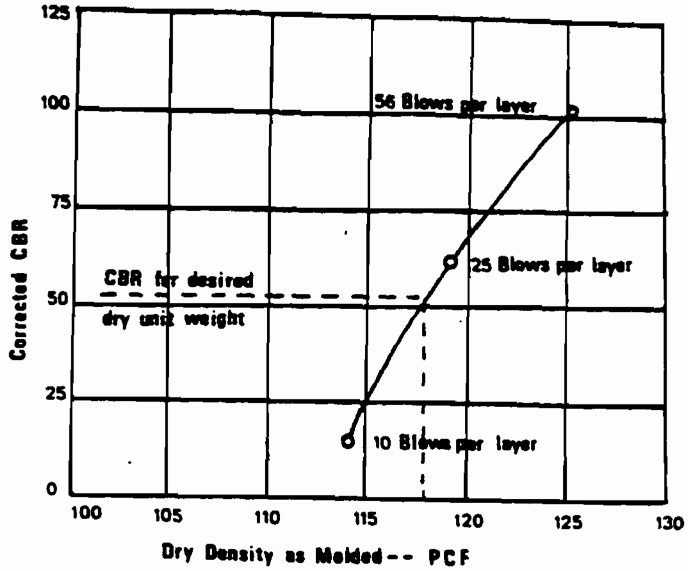


FIG. 3 Dry Density Versus CBR

8.3 Apply the load on the penetration piston so that the rate of penetration is approximately 0.05 in. (1.27 mm)/min. Record the load readings at penetrations of 0.025 in. (0.64 mm), 0.050 in. (1.27 mm), 0.075 in. (1.91 mm), 0.100 in. (2.54 mm), 0.125 in. (3.18 mm), 0.150 in. (3.81 mm), 0.175 in. (4.45 mm), 0.200 in. (5.08 mm), 0.300 in. (7.62 mm), 0.400 in. (10.16 mm) and 0.500 in. (12.70 mm). Note the maximum load and penetration if it occurs for a penetration of less than 0.500 in. (12.70 mm). With manually operated loading devices, it may be necessary to take load readings at closer intervals to control the rate of penetration. Measure the depth of piston penetration into the soil by putting a ruler into the indentation and measuring the difference from the top of the soil to the bottom of the indentation. If the depth does not closely match the depth of penetration gage, determine the cause and test a new sample.

8.4 Remove the soil from the mold and determine the moisture content of the top 1-in. (25.4-mm) layer. Take a moisture content sample in accordance with Test Methods D 698 or D 1557 if the average moisture content is desired. Each moisture content sample shall weigh not less than 100 g for fine-grained soils nor less than 500 g for granular soils.

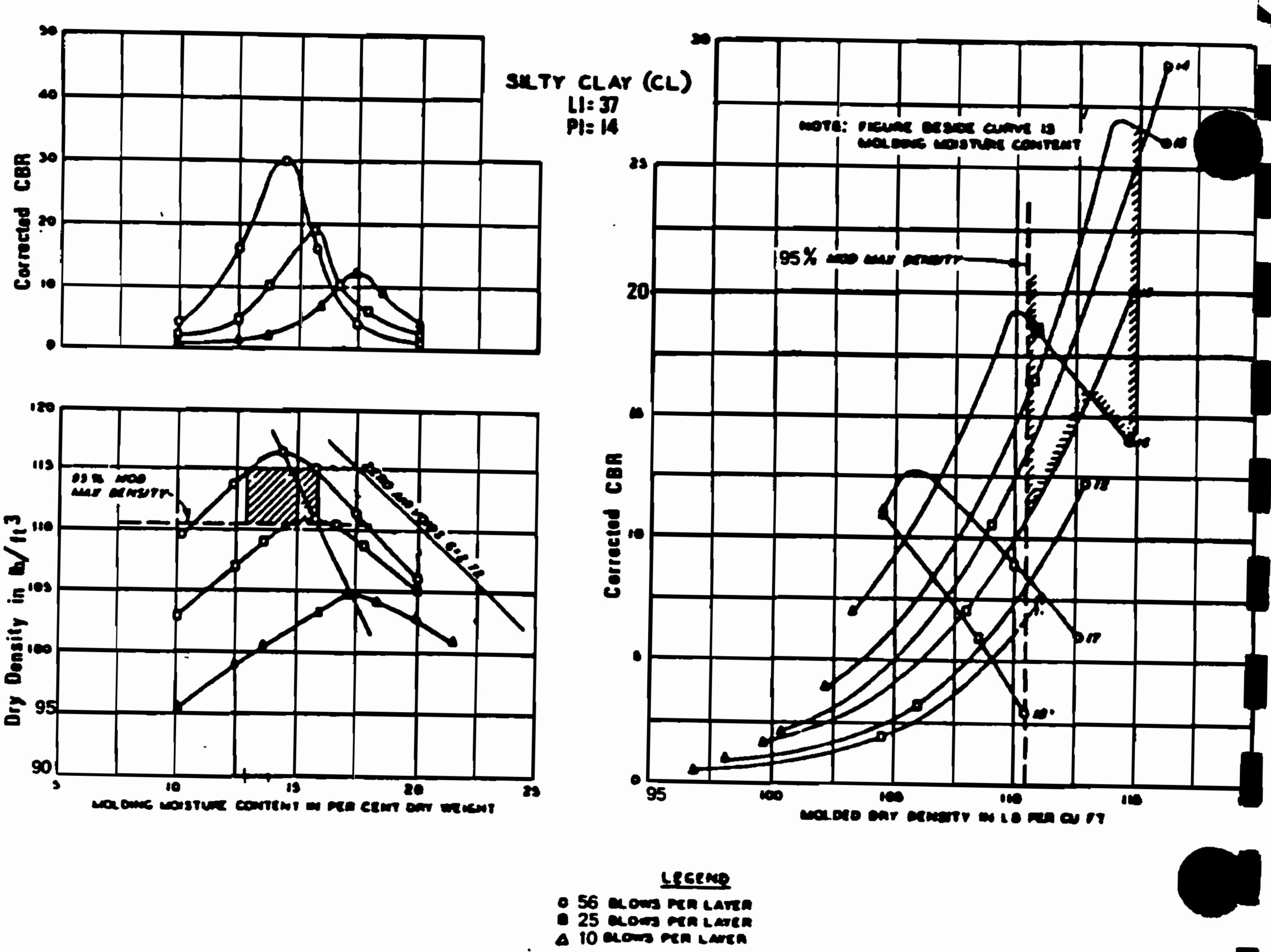
NOTE 6—The load readings at penetrations of over 0.300 in. (7.6 mm) may be omitted if the testing machine's capacity has been reached.

9. Calculation

9.1 *Load-Penetration Curve*—Calculate the penetration stress in pounds per square inch or megapascals and plot the stress-penetration curve. In some instances, the stresspenetration curve may be concave upward initially, because of surface irregularities or other causes, and in such cases the zero point shall be adjusted as shown in Fig. 2.

NOTE 7—Fig. 2 should be used as an example of correction of load-penetration curves only. It is not meant to imply that the 0.2-in. penetration is always more than the 0.1-in. penetration.

9.2 *Bearing Ratio*—Using corrected stress values taken from the stress penetration curve for 0.100 in. (2.54 mm) and



NOTE 1—Surcharge = 50 lb soaking and penetration. All samples soaked top and bottom four days. All samples compacted in 5 layers, 10-lb hammer, 18-in. drop in CBR mold.

FIG. 4 Determining CBR for Water Content Range and Minimum Dry Unit Weight

0.200 in. (5.08 mm) penetrations, calculate the bearing ratios for each by dividing the corrected stresses by the standard stresses of 1000 psi (6.9 MPa) and 1500 psi (10.3 MPa) respectively, and multiplying by 100. Also, calculate the bearing ratios for the maximum stress, if the penetration is less than 0.200 in. (5.08 mm) interpolating the standard stress. The bearing ratio reported for the soil is normally the one at 0.100 in. (2.54 mm) penetration. When the ratio at 0.200 in. (5.08 mm) penetration is greater, rerun the test. If the check test gives a similar result, use the bearing ratio at 0.200 in. (5.08 mm) penetration.

NOTE 8—If bearing ratio values at penetrations of 0.300 (7.62 mm), 0.400 (10.16 mm) and 0.500 in. (12.7 mm) are desired, the corrected stress values of these penetrations should be divided by the standard stresses of 1900 psi (13.1 MPa), 2300 psi (15.9 MPa), 2600 psi (17.9 MPa), respectively, and multiplied by 100.

9.3 *Design CBR for One Water Content Only*—Using the data obtained from the three specimens, plot the CBR versus molded dry unit weight relation as illustrated in Fig. 3. Determine the design CBR at the percentage of the maximum dry unit weight requested.

9.4 *Design CBR for Water Content Range*— Plot the data from the tests at the three compactive efforts as shown in Fig. 4. The data plotted as shown represents the response of the soil over the range of water content specified. Select the CBR for reporting as the lowest CBR within the specified water content range having a dry unit weight between the specified minimum and the dry unit weight produced by compaction within the water content range.

10. Report

10.1 The report shall include the following:

10.1.1 Method used for preparation and compaction of specimen: Test Methods D 698 or D 1557, or other, with description.

10.1.2 Condition of sample (unsoaked or soaked).

10.1.3 Dry density (unit weight) of sample before soaking, kg/m³ (lb/ft³).

10.1.4 Dry density (unit weight) of sample after soaking kg/m³ (lb/ft³).

10.1.5 Moisture content of sample in percent:

10.1.5.1 Before compaction.

10.1.5.2 After compaction.

10.1.5.3 Top 1-in (25.4-mm) layer after soaking.

10.1.5.4 Average after soaking.

10.1.6 Swell (percentage of initial height).

10.1.7 Bearing ratio of sample (unsoaked or soaked), percent.

10.1.8 Surcharge amount.

10.1.9 Any special sample preparation and testing procedures (for example: for self cementing materials).

10.1.10 Sample identification (location, boring number, etc.).

10.1.11 Any pertinent testing done to identify the sample such as: soil classifications per Test Method D 2487, visual classification per Practice D 2488, Atterberg limits per Test Method D 4318, gradation per Method D 422 etc.

10.1.12 The percent material retained on the ln[]-in. (19-mm) sieve for those cases where scalping and replacement is used.

11. Precision and Bias

11.1 No available methods provide absolute values for the soil bearing strength derived by this test method; therefore, there is no meaningful way to obtain an evaluation of bias.

11.2 At present, sufficient data for determining the precision of this test method has not been gathered. Users are encouraged to submit data to the subcommittee for inclusion in the statement. One user, based on seven repetitions, has developed a IS % of 8.2 % (compacted per Test Method D 698) and 5.9 % (compacted per Test Method D 1557). See Appendix X1 for the data used.

12. Keywords

12.1 This standard is indexed under the following terms:

California Bearing Ratio	Used For, Narrower Term
Pavement Subgrade	Used For, Narrower Term
Subgrade	Related Term, Broader Term
Pavement Subbase	Used For, Narrower Term
Subbase	Used For, Broader Term
Pavement Base Course	Used For, Narrower Term
Base Course	Used For, Broader Term
Strength of Soil	Used For
Pavement Design	Used For, Narrower Term
Acceptance Tests	Used For
Bearing Capacity	Used For
Materials Evaluations	Used For
Bearing Ratio	Used For, Broader Term
Load Penetration Curve	Used For
Design	Used For, Broader Term
Earthfill	Related To
Cohesive Soils	Used For
Compressive Strength	Used For
Flexible Pavements	Used For
Foundation Investigations	Used For
Soil Tests	Used For

APPENDIX

(Nonmandatory Information)

X1. Compactive Effort

STANDARD (D698) CBR (x)	(x-x)	$(x-x)^2$	MODIFIED (D1557) CBR (x)	(x-x)	$(x-x)^2$
16.7	.5	.25	77.0	3	9
15.7	1.5	2.25	70.2	3.8	14.44
18.2	1.0	1	80.8	6.8	46.24
18.2	1.0	1	68.2	5.8	33.64
18.8	1.6	2.56	76.7	2.7	7.29
19.3	2.1	4.41	71.7	2.3	5.29
17.9	0.7	.49	73.3	0.7	.49
x =124.8	$(x-x)^2$	11.96	x =517.9	$(x-x)^2$	116.39
x = 17.2			x = 74.0		

$$S = \frac{11.96}{6} \qquad S = \frac{116.39}{6} = 19.39$$

IS (one sigma) = 1.41 IS = 4.4

$$IS\ \% = \frac{1.41}{17.2} \times 100 = 8.2\% \qquad IS\ \% = \frac{4.4}{74} \times 100 = 5.9\%$$

D2S % = 22.8% D2S % = 16.7%

NOTES:
- All Material passed the #10 sieve
- Over 90% of all material passed the #40 sieve
- Method A of AASHTO T99 & T180 used
- Unit weights were 110 PCF ± (D698) and 122 PCF ± (D1557)
- 7 test repetitions
- The above data is from one user
- The (IS) and (D2S) limits represent the limits as described in ASTM Practice C670.

FIG. X1.1 Compactive Effort

SUMMARY OF CHANGES

(*1*) Terminology D 653 was added to Section 2.
(2) Wording in Fig. 1 was changed from "equally spaced" to "uniformly spaced" to match the wording in the text.
(*3*) Section 5.1 was revised and a new Table 1 was added. Table 2 is the former Table 1.
(*4*) This Summary of Changes section has been added.

Designation: D 2166 – 85

Standard Test Method for
UNCONFINED COMPRESSIVE STRENGTH OF COHESIVE SOIL[1]

This standard is issued under the fixed designation D 2166; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method covers the determination of the unconfined compressive strength of cohesive soil in the undisturbed, remolded, or compacted condition, using strain-controlled application of the axial load.

1.2 This test method provides an approximate value of the strength of cohesive soils in terms of total stresses.

1.3 This test method is applicable only to cohesive materials which will not expel bleed water (water expelled from the soil due to deformation or compaction) during the loading portion of the test and which will retain intrinsic strength after removal of confining pressures, such as clays or cemented soils. Dry and crumbly soils, fissured or varved materials, silts, peats, and sands cannot be tested with this method to obtain valid unconfined compression strength values.

NOTE 1—The determination of the unconsolidated, undrained strength of cohesive soils with lateral confinement is covered by Test Method D 2850.

1.4 This test method is not a substitute for Test Method D 2850.

1.5 The values stated in SI units are to be regarded as the standard. The values stated in inch-pound units are approximate.

1.6 *This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of whoever uses this standard to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Applicable Documents

2.1 *ASTM Standards:*

D 422 Method for Particle-Size Analysis of Soils[2]
D 653 Terms and Symbols Relating to Soil and Rock[2]
D 854 Test Method for Specific Gravity of Soils[2]
D 1587 Practice for Thin-Walled Tube Sampling of Soils[2]
D 2216 Method for Laboratory Determination of Water (Moisture) Content of Soil, Rock, and Soil-Aggregate Mixtures[2]
D 2487 Test Method for Classification of Soils for Engineering Purposes[2]
D 2488 Practice for Description and Identification of Soils (Visual-Manual Procedure)[2]
D 2850 Test Method for Unconsolidated, Undrained Compressive Strength of Cohesive Soils in Triaxial Compression[2]
D 4220 Practices for Preserving and Transporting Soil Samples[2]
D 4318 Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils[2]

3. Terminology

3.1 Refer to Terms and Symbols D 653 for standard definitions of terms.

[1] This test method is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.05 on Structural Properties of Soils.

Current edition approved July 26, 1985. Published September 1985. Originally published as D 2166 – 63T. Last previous edition D 2166 – 66 (1979)[ε1].

[2] *Annual Book of ASTM Standards*, Vol 04.08.

3.2 *Descriptions of Terms Specific to Standard:*

3.2.1 *unconfined compressive strength (q*
the compressive stress at which an unconfi
cylindrical specimen of soil will fail in a sir
compression test. In this test method, unconfi
compressive strength is taken as the maxim
load attained per unit area or the load per u
area at 15 % axial strain, whichever is secu
first during the performance of a test.

3.2.2 *shear strength (s_u)*—for unconfir
compressive strength test specimens, the sh
strength is calculated to be ½ of the compress
stress at failure, as defined in 3.2.1.

4. Significance and Use

4.1 The primary purpose of the unconfin
compression test is to quickly obtain the appro
imate compressive strength of soils that posse
sufficient cohesion to permit testing in the u
confined state.

4.2 Samples of soils having slickensided c
fissured structure, samples of some types of loes
very soft clays, dry and crumbly soils and varve
materials, or samples containing significant por
tions of silt or sand, or both (all of which usuall
exhibit cohesive properties), frequently displa
higher shear strengths when tested in accordanc
with Test Method D 2850. Also, unsaturatec
soils will usually exhibit different shear strength
when tested in accordance with Test Method
D 2850.

4.3 If both an undisturbed and a remolded test are performed on the same sample, the sensitivity of the material can be determined. This method of determining sensitivity is suitable only for soils that can retain a stable specimen shape in the remolded state.

NOTE 2—For soils that will not retain a stable shape, a vane shear test or Test Method D 2850 can be used to determine sensitivity.

5. Apparatus

5.1 *Compression Device*—The compression device may be a platform weighing scale equipped with a screw-jack-activated load yoke, a hydraulic loading device, or any other compression device with sufficient capacity and control to provide the rate of loading prescribed in 7.1. For soil with an unconfined compressive strength of less than 100 kPa (1.0 ton/ft²) the compression device shall be capable of measuring

;TRENGTH OF COHESIVE

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pplicable Documents

1 *ASTM Standards:*

422 Method for Particle-Size Analysis of Soils[2]

653 Terms and Symbols Relating to Soil and Rock[2]

854 Test Method for Specific Gravity of Soils[2]

1587 Practice for Thin-Walled Tube Sampling of Soils[2]

2216 Method for Laboratory Determination of Water (Moisture) Content of Soil, Rock, and Soil-Aggregate Mixtures[2]

2487 Test Method for Classification of Soils for Engineering Purposes[2]

2488 Practice for Description and Identification of Soils (Visual-Manual Procedure)[2]

2850 Test Method for Unconsolidated, Undrained Compressive Strength of Cohesive Soils in Triaxial Compression[2]

4220 Practices for Preserving and Transporting Soil Samples[2]

4318 Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils[2]

Terminology

3.1 Refer to Terms and Symbols D 653 for ndard definitions of terms.

[1] This test method is under the jurisdiction of ASTM Comtee D-18 on Soil and Rock and is the direct responsibility of ɔcommittee D18.05 on Structural Properties of Soils.

Current edition approved July 26, 1985. Published Septem- 1985. Originally published as D 2166 – 63T. Last previous tion D 2166 – 66 (1979)ᵉ¹.

[2] *Annual Book of ASTM Standards*, Vol 04.08.

3.2 *Descriptions of Terms Specific to this Standard:*

3.2.1 *unconfined compressive strength* (q_u)—the compressive stress at which an unconfined cylindrical specimen of soil will fail in a simple compression test. In this test method, unconfined compressive strength is taken as the maximum load attained per unit area or the load per unit area at 15 % axial strain, whichever is secured first during the performance of a test.

3.2.2 *shear strength* (s_u)—for unconfined compressive strength test specimens, the shear strength is calculated to be ½ of the compressive stress at failure, as defined in 3.2.1.

4. Significance and Use

4.1 The primary purpose of the unconfined compression test is to quickly obtain the approximate compressive strength of soils that possess sufficient cohesion to permit testing in the unconfined state.

4.2 Samples of soils having slickensided or fissured structure, samples of some types of loess, very soft clays, dry and crumbly soils and varved materials, or samples containing significant portions of silt or sand, or both (all of which usually exhibit cohesive properties), frequently display higher shear strengths when tested in accordance with Test Method D 2850. Also, unsaturated soils will usually exhibit different shear strengths when tested in accordance with Test Method D 2850.

4.3 If both an undisturbed and a remolded test are performed on the same sample, the sensitivity of the material can be determined. This method of determining sensitivity is suitable only for soils that can retain a stable specimen shape in the remolded state.

NOTE 2—For soils that will not retain a stable shape, a vane shear test or Test Method D 2850 can be used to determine sensitivity.

5. Apparatus

5.1 *Compression Device*—The compression device may be a platform weighing scale equipped with a screw-jack-activated load yoke, a hydraulic loading device, or any other compression device with sufficient capacity and control to provide the rate of loading prescribed in 7.1. For soil with an unconfined compressive strength of less than 100 kPa (1.0 ton/ft²) the compression device shall be capable of measuring the compressive stress to within 1 kPa (0.01 ton/ft²). For soil with an unconfined compressive strength of 100 kPa (1.0 ton/ft²) or greater, the compression device shall be capable of measu[illegible] the compressive stress to the nearest 5 kPa ([illegible] ton/ft²).

5.2 *Sample Extruder*, capable of extruding the soil core from the sampling tube in the same direction of travel in which the sample entered the tube, at a uniform rate, and with negligible disturbance of the sample. Conditions at the time of sample removal may dictate the direction of removal, but the principal concern is to keep the degree of disturbance negligible.

5.3 *Deformation Indicator*—The deformation indicator shall be a dial indicator graduated to 0.03 mm (0.001 in.) or better and having a travel range of at least 20 % of the length of the test specimen, or some other measuring device, such as an electronic deformation measuring device, meeting these requirements.

5.4 *Dial Comparator*, or other suitable device, for measuring the physical dimensions of the specimen to within 0.1 % of the measured dimension.

NOTE 3—Vernier calipers are not recommended for soft specimens, which will deform as the calipers are set on the specimen.

5.5. *Timer*—A timing device indicating the elapsed testing time to the nearest second shall be used for establishing the rate of strain application prescribed in 7.1.

5.6 *Balance*—The balance used to weigh [illegible]imens shall determine the mass of the spec[illegible] to within 0.1 % of its total mass.

5.7 *Equipment*, as specified in Method D 2216.

5.8 *Miscellaneous Apparatus*, including specimen trimming and carving tools, remolding apparatus, water content cans, and data sheets, as required.

6. Preparation of Test Specimens

6.1 *Specimen Size*—Specimens shall have a minimum diameter of 30 mm (1.3 in.) and the largest particle contained within the test specimen shall be smaller than one tenth of the specimen diameter. For specimens having a diameter of 72 mm (2.8 in.) or larger, the largest particle size shall be smaller than one sixth of the specimen diameter. If, after completion of a test on an undisturbed specimen, it is found, based on visual observation, that larger particles than permitted are present, indicate this information in the remarks section of the report of test data (Note 4). The height-to-diameter ratio shall be between 2 and 2.5. Determine the average height and diameter of the test specimen using the apparatus specified in 5.4. Take a minimum of three height measurements (120° apart), and at least three diameter measurements at the quarter points of the height.

NOTE 4—If large soil particles are found in the sample after testing, a particle-size analysis performed in accordance with Method D 422 may be performed to confirm the visual observation and the results provided with the test report.

6.2 *Undisturbed Specimens*—Prepare undisturbed specimens from large undisturbed samples or from samples secured in accordance with ctice D 1587 and preserved and transported ccordance with the practices for Group C nples in Practices D 4220. Tube specimens may be tested without trimming except for the squaring of ends, if conditions of the sample justify this procedure. Handle specimens carefully to prevent disturbance, changes in cross section, or loss of water content. If compression or any type of noticeable disturbance would be caused by the extrusion device, split the sample tube lengthwise or cut it off in small sections to facilitate removal of the specimen without disturbance. Prepare carved specimens without disturbance, and whenever possible, in a humidity-controlled room. Make every effort to prevent any change in water content of the soil. Specimens shall be of uniform circular cross section with ends perpendicular to the longitudinal axis of the specimen. When carving or trimming, remove any small pebbles or shells encountered. Carefully fill voids on the surface of the specimen with remolded soil obtained from the trimmings. When pebbles or crumbling result in excessive irregularity at the ends, cap the specimen with a minimum thickness of plaster of paris, hydrostone, or similar material. When sample condition permits, a vertical lathe that will accommodate the total sample may be used as an aid in ing the specimen to the required diameter. e prevention of the development of appre- e capillary forces is deemed important, seal the specimen with a rubber membrane, thin plastic coatings, or with a coating of grease or sprayed plastic immediately after preparation and during the entire testing cycle. Determine the mass and dimensions of the test specimen. If the specimen is to be capped, its mass and dimensions should be determined before capping. If the entire test specimen is not to be used for determination of water content, secure a representative sample of cuttings for this purpose, placing them immediately in a covered container. The water content determination shall be performed in accordance with Method D 2216.

6.3 *Remolded Specimens*—Specimens may be prepared either from a failed undisturbed specimen or from a disturbed sample, providing it is representative of the failed undisturbed specimen. In the case of failed undisturbed specimens, wrap the material in a thin rubber membrane and work the material thoroughly with the fingers to assure complete remolding. Avoid entrapping air in the specimen. Exercise care to obtain a uniform density, to remold to the same void ratio as the undisturbed specimen, and to preserve the natural water content of the soil. Form the disturbed material into a mold of circular cross section having dimensions meeting the requirements of 6.1. After removal from the mold, determine the mass and dimensions of the test specimens.

6.4 *Compacted Specimens*—Specimens shall be prepared to the predetermined water content and density prescribed by the individual assigning the test (Note 5). After a specimen is formed, trim the ends perpendicular to the longitudinal axis, remove from the mold, and determine the mass and dimensions of the test specimen.

NOTE 5—Experience indicates that it is difficult to compact, handle, and obtain valid results with specimens that have a degree of saturation that is greater than 90 %.

7. Procedure

7.1 Place the specimen in the loading device so that it is centered on the bottom platen. Adjust the loading device carefully so that the upper platen just makes contact with the specimen. Zero the deformation indicator. Apply the load so as to produce an axial strain at a rate of ½ to 2 %/min. Record load, deformation, and time values at sufficient intervals to define the shape of the stress-strain curve (usually 10 to 15 points are sufficient). The rate of strain should be chosen so that the time to failure does not exceed about

15 min (Note 6). Continue loading until the values decrease with increasing strain, or ı 15 % strain is reached. The rate of strain usec testing sealed specimens may be decrease deemed desirable for better test results. Indi the rate of strain in the report of the test data required in 9.1.7. Determine the water cont of the test specimen using the entire specim unless representative cuttings are obtained this purpose, as in the case of undisturbed spe mens. Indicate on the test report whether ı water content sample was obtained before after the shear test, as required in 9.1.2.

NOTE 6—Softer materials that will exhibit lar deformation at failure should be tested at a higher r of strain. Conversely, stiff or brittle materials that w exhibit small deformations at failure should be test at a lower rate of strain.

7.2 Make a sketch, or take a photo, of the te specimen at failure showing the slope angle c the failure surface if the angle is measurable.

7.3 A copy of a sample data sheet is include in Appendix X1. Any data sheet can be usec provided the form contains all the required data

8. Calculations

8.1 Calculate the axial strain, ϵ_1, to the neares 0.1 %, for a given applied load, as follows:

$$\epsilon_1 = \Delta L / L_0$$

where:

ΔL = length change of specimen as read from deformation indicator, mm (in.), and

L_0 = initial length of test specimen, mm (in.).

8.2 Calculate the average cross-sectional area, A, for a given applied load, as follows:

$$A = A_0/(1 - \epsilon_1)$$

where:

A_0 = initial average cross-sectional area of the specimen, mm² (in.²), and

ϵ_1 = axial strain for the given load, %.

8.3 Calculate the compressive stress, σ_c, to three significant figures, or nearest 1 kPa (0.01 ton/ft²), for a given applied load, as follows:

$$\sigma_c = (P/A)$$

where:

P = given applied load, kPa (ton/ft²),

A = corresponding average cross-sectional area mm² (in.²).

8.4 *Graph*—If desired, a graph showing the relationship between compressive stress (ordistic immediately after preparation and during entire testing cycle. Determine the mass and iensions of the test specimen. If the specimen ɔ be capped, its mass and dimensions should determined before capping. If the entire test cimen is not to be used for determination of er content, secure a representative sample of ings for this purpose, placing them immedi-y in a covered container. The water content ermination shall be performed in accordance ı Method D 2216.

.3 *Remolded Specimens*—Specimens may prepared either from a failed undisturbed imen or from a disturbed sample, providing representative of the failed undisturbed spec-n. In the case of failed undisturbed speci-ıs, wrap the material in a thin rubber mem-ie and work the material thoroughly with the ers to assure complete remolding. Avoid en-ping air in the specimen. Exercise care to in a uniform density, to remold to the same ratio as the undisturbed specimen, and to erve the natural water content of the soil. n the disturbed material into a mold of cir- cross section having dimensions meeting equirements of 6.1. After removal from the l, determine the mass and dimensions of the pecimens.

ł *Compacted Specimens*—Specimens shall epared to the predetermined water content density prescribed by the individual assign-ie test (Note 5). After a specimen is formed, the ends perpendicular to the longitudinal remove from the mold, and determine the and dimensions of the test specimen.

TE 5—Experience indicates that it is difficult to act, handle, and obtain valid results with speci-that have a degree of saturation that is greater 0 %.

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Place the specimen in the loading device it it is centered on the bottom platen. Adjust ɔading device carefully so that the upper ı just makes contact with the specimen. the deformation indicator. Apply the load to produce an axial strain at a rate of ½ to nin. Record load, deformation, and time ; at sufficient intervals to define the shape stress-strain curve (usually 10 to 15 points ficient). The rate of strain should be chosen t the time to failure does not exceed about

15 min (Note 6). Continue loading until the load values decrease with increasing strain, or until 15 % strain is reached. The rate of strain used for testing sealed specimens may be decreased if deemed desirable for better test results. Indicate the rate of strain in the report of the test data, as required in 9.1.7. Determine the water content of the test specimen using the entire specimen, unless representative cuttings are obtained for this purpose, as in the case of undisturbed speci-mens. Indicate on the test report whether the water content sample was obtained before or after the shear test, as required in 9.1.2.

NOTE 6—Softer materials that will exhibit larger deformation at failure should be tested at a higher rate of strain. Conversely, stiff or brittle materials that will exhibit small deformations at failure should be tested at a lower rate of strain.

7.2 Make a sketch, or take a photo, of the test specimen at failure showing the slope angle of the failure surface if the angle is measurable.

7.3 A copy of a sample data sheet is included in Appendix X1. Any data sheet can be used, provided the form contains all the required data.

8. Calculations

8.1 Calculate the axial strain, ϵ_1, to the nearest 0.1 %, for a given applied load, as follows:

$$\epsilon_1 = \Delta L / L_0$$

where:

ΔL = length change of specimen as read from deformation indicator, mm (in.), and

L_0 = initial length of test specimen, mm (in.).

8.2 Calculate the average cross-sectional area, A, for a given applied load, as follows:

$$A = A_0/(1 - \epsilon_1)$$

where:

A_0 = initial average cross-sectional area of the specimen, mm² (in.²), and

ϵ_1 = axial strain for the given load, %.

8.3 Calculate the compressive stress, σ_c, to three significant figures, or nearest 1 kPa (0.01 ton/ft²), for a given applied load, as follows:

$$\sigma_c = (P/A)$$

where:

P = given applied load, kPa (ton/ft²),

A = corresponding average cross-sectional area mm² (in.²).

8.4 *Graph*—If desired, a graph showing the relationship between compressive stress (ordinate) and axial strain (abscissa) may be plotted. Select the maximum value of compressive stress or the compressive stress at 15 % axial strain, whichever is secured first, and report as the unconfined compressive strength, q_u. Whenever it is considered necessary for proper interpretation, include the graph of the stress-strain data as part of the data reported.

8.5 If the unconfined compressive strength is determined, the sensitivity, S_T, is calculated as follows:

$$S_T = \frac{q_u \text{ (undisturbed specimen)}}{q_u \text{ (remolded specimen)}}$$

9. Report

9.1 The report should include the following:

9.1.1 Identification and visual description of the specimen, including soil classification, symbol, and whether the specimen is undisturbed, remolded, compacted, etc. Also include specimen identifying information, such as project, location, boring number, sample number, depth, etc. Visual descriptions shall be made in accordance with Practice D 2488,

9.1.2 Initial dry density and water content (specify if the water content specimen was obtained before or after shear, and whether from cuttings or the entire specimen),

9.1.3 Degree of saturation (Note 7), if computed,

NOTE 7—The specific gravity determined in accordance with Test Method D 854 is required for calculation of the degree of saturation.

9.1.4 Unconfined compressive strength and shear strength,

9.1.5 Average height and diameter of specimen,

9.1.6 Height-to-diameter ratio,

9.1.7 Average rate of strain to failure, %,

9.1.8 Strain at failure, %,

9.1.9 Liquid and plastic limits, if determined, in accordance with Test Method D 4318,

9.1.10 Failure sketch or photo,

9.1.11 Stress-strain graph, if prepared,

9.1.12 Sensitivity, if determined,

9.1.13 Particle size analysis, if determined, in accordance with Method D 422, and

9.1.14 *Remarks*—Note any unusual conditions or other data that would be considered necessary to properly interpret the results obtained, for example, slickensides, stratification, shells, pebbles, roots, or brittleness, the type of failure (that is, bulge, diagonal shear, etc.).

10. Precision and Bias

10.1 No method presently exists to evaluate the precision of a group of unconfined compression tests on undisturbed specimens due to specimen variability. Undisturbed soil specimens from apparently homogeneous soil deposits at the same location often exhibit significantly different strength and stress-strain properties.

10.2 A suitable test material and method of specimen preparation have not been developed for the determination of laboratory variances due to the difficulty in producing identical cohesive soil specimens. No estimates of precision for this test method are available.

APPENDIX

(Nonmandatory Information)

X1. Example Data Sheet

UNCONFINED COMPRESSION TEST—UI

Name ______________ Date ______________ Job No. ______________

Location ______________________________

Boring No. ______________ Sample No. ______________ Depth/Elev. ______________

Description of Sample ______________________________

____

Proving Ring No. ______________ Apparatus No. ______________

Water Content Determination

Tare No. ______________

Wt. Specimen Wet + Tare ______________

Wt. Specimen Dry + Tare ______________

Wt. Water ______________

Wt. Tare ______________

Wt. Specimen Wet ______________

Wt. Specimen Dry ______________

Water Content in % Dry Wt.

at 105°C ______________%

Wet Density ______________

Dry Density ______________

Unconfined Compressive Strength

Initial Diameter D_o ______________

Initial Area A_o ______________

Initial Height L_o ______________

Initial Volume V_o ______________

Specific Gravity ______________

$$\text{Stress} = \frac{\text{Load}}{\text{Corr. Area}}$$

Data sheet continued

Test Data

Unit Strain $\frac{\Delta L}{L_o}$ $\frac{L}{D}$ =

Elapsed Time-min	Load Dial	Axial Load	Strain Dial	T S:

Type of Sample ______________

Strain Rate ______________%/Min

Remarks ______________

____

om apparently homogeneous soil deposits at ıe same location often exhibit significantly dif- rent strength and stress-strain properties.

10.2 A suitable test material and method of ɔecimen preparation have not been developed ır the determination of laboratory variances due ı the difficulty in producing identical cohesive ɔil specimens. No estimates of precision for this st method are available.

ıIX

ıformation)

ıta Sheet

ESSION TEST—UI

Job No.

Depth/Elev.

Apparatus No.

Water Content in % Dry Wt.

at 105°C ____%

Wet Density ____

Dry Density ____

Specific Gravity ____

$$\text{Stress} = \frac{\text{Load}}{\text{Corr. Area}}$$

tinued

Test Data Unit Strain $\frac{\Delta L}{L_o}$ $\frac{L}{D}$ = ____ Corr. Area = $\frac{A_o}{1 - \text{Unit Strain}}$

Elapsed Time-min	Load Dial	Axial Load	Strain Dial	Total Strain	Unit Strain	Corrected Area	Stress	

Type of Sample ____

Attach a photo or sketch of the specimen after failure to this form

Strain Rate ____ %/Min

Remarks ____

Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass[1]

This standard is issued under the fixed designation D 2216; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope *

1.1 This test method covers the laboratory determination of the water (moisture) content by mass of soil, rock, and similar materials where the reduction in mass by drying is due to loss of water except as noted in 1.4, 1.5, and 1.7. For simplicity, the word "material" hereinafter also refers to either soil or rock, whichever is most applicable.

1.2 Some disciplines, such as soil science, need to determine water content on the basis of volume. Such determinations are beyond the scope of this test method.

1.3 The water content of a material is defined in 3.2.1.

1.4 The term "solid material" as used in geotechnical engineering is typically assumed to mean naturally occurring mineral particles of soil and rock that are not readily soluble in water. Therefore, the water content of materials containing extraneous matter (such as cement, and the like) may require special treatment or a qualified definition of water content. In addition, some organic materials may be decomposed by oven drying at the standard drying temperature for this method (110°C). Materials containing gypsum (calcium sulfate dihydrate or other compounds having significant amounts of hydrated water) may present a special problem as this material slowly dehydrates at the standard drying temperature (110°C) and at very low relative humidities, forming a compound (calcium sulfate hemihydrate) which is not normally present in natural materials except in some desert soils. In order to reduce the degree of dehydration of gypsum in those materials containing gypsum, or to reduce decomposition in highly organic soils, it may be desirable to dry these materials at 60°C or in a desiccator at room temperature. Thus, when a drying temperature is used which is different from the standard drying temperature as defined by this test method, the resulting water content may be different from standard water content determined at the standard drying temperature.

NOTE 1—Test Methods D 2974 provides an alternate procedure for determining water content of peat materials.

1.5 Materials containing water with substantial amounts of soluble solids (such as salt in the case of marine sediments) when tested by this method will give a mass of solids which includes the previously soluble solids. These materials require special treatment to remove or account for the presence of precipitated solids in the dry mass of the specimen, or a qualified definition of water content must be used. For example, see Noorany[2] regarding information on marine soils.

1.6 This test method requires several hours for proper drying of the water content specimen. Test Method D 4643 provides for drying of the test specimen in a microwave oven which is a shorter process. Also see Gilbert[3] for details on the background of this test method.

1.7 This standard requires the drying of material in an oven at high temperatures. If the material being dried is contaminated with certain chemicals, health and safety hazards can exist. Therefore, this standard should not be used in determining the water content of contaminated soils unless adequate health and safety precautions are taken.

1.8 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

D 653 Terminology Relating to Soil, Rock, and Contained Fluids[4]

D 2974 Test Methods for Moisture, Ash, and Organic Matter of Peat and Other Organic Soils[4]

D 4220 Practice for Preserving and Transporting Soil Samples[4]

D 4318 Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils[4]

D 4643 Test Method for Determination of Water (Moisture) Content of Soil by the Microwave Oven Method[4]

D 4753 Specification for Evaluating, Selecting, and Specifying Balances and Scales for Use in Soil and Rock Testing[4]

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[1] This test method is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.03 on Texture, Plasticity and Density Characteristics of Soils.

Current edition approved Feb. 10, 1998. Published January 1999. Originally published as D 2216 – 63 T. Last previous edition D 2216 – 92.

[2] Noorany, I., "Phase Relations in Marine Soils", Journal of Geotechnical Engineering, ASCE, Vol. 110, No. 4, April 1984, pp. 539–543.

[3] Gilbert, P.A., "Computer Controlled Microwave Oven System for Rapid Water Content Determination", Tech. Report GL-88-21, Department of the Army, Waterways Experiment Station, Corps of Engineers, Vicksburg, MS, November 1988.

[4] *Annual Book of ASTM Standards*, Vol 04.08.

*A Summary of Changes section appears at the end of this standard.

D 6026 Guide for Using Significant Digits in Calculating and Reporting Geotechnical Test Data[5]

E 145 Specification for Gravity-Convection And Forced-Ventilation Ovens[6]

3. Terminology

3.1 Refer to Terminology D 653 for standard definitions of terms.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *water content (of a material)*—the ratio expressed as a percent of the mass of "pore" or "free" water in a given mass of material to the mass of the solid material. A standard temperature of 110° ± 5°C is used to determine these masses.

4. Summary of Test Method

4.1 A test specimen is dried in an oven at a temperature of 110° ± 5°C to a constant mass. The loss of mass due to drying is considered to be water. The water content is calculated using the mass of water and the mass of the dry specimen.

5. Significance and Use

5.1 For many materials, the water content is one of the most significant index properties used in establishing a correlation between soil behavior and its index properties.

5.2 The water content of a material is used in expressing the phase relationships of air, water, and solids in a given volume of material.

5.3 In fine-grained (cohesive) soils, the consistency of a given soil type depends on its water content. The water content of a soil, along with its liquid and plastic limits as determined by Test Method D 4318, is used to express its relative consistency or liquidity index.

6. Apparatus

6.1 *Drying Oven*, thermostatically-controlled, preferably of the forced-draft type, meeting the requirements of Specification E 145 and capable of maintaining a uniform temperature of 110 ± 5°C throughout the drying chamber.

6.2 *Balances*—All balances must meet the requirements of Specification D 4753 and this section. A Class GP1 balance of 0.01g readability is required for specimens having a mass of up to 200 g (excluding mass of specimen container) and a Class GP2 balance of 0.1g readability is required for specimens having a mass over 200 g. However, the balance used may be controlled by the number of significant digits needed (see 8.2.1 and 12.1.2).

6.3 *Specimen Containers*—Suitable containers made of material resistant to corrosion and change in mass upon repeated heating, cooling, exposure to materials of varying pH, and cleaning. Unless a dessicator is used, containers with close-fitting lids shall be used for testing specimens having a mass of less than about 200 g; while for specimens having a mass greater than about 200 g, containers without lids may be used (see Note 7). One container is needed for each water content determination.

NOTE 2—The purpose of close-fitting lids is to prevent loss of moisture from specimens before initial mass determination and to prevent absorption of moisture from the atmosphere following drying and before final mass determination.

6.4 *Desiccator*—A desiccator cabinet or large desiccato of suitable size containing silica gel or anhydrous cal sulfate. It is preferable to use a desiccant which changes color to indicate it needs reconstitution. See 10.5.

NOTE 3—Anhydrous calcium sulfate is sold under the trade name Drierite.

6.5 *Container Handling Apparatus*, gloves, tongs, or suitable holder for moving and handling hot containers after drying.

6.6 *Miscellaneous*, knives, spatulas, scoops, quartering cloth, sample splitters, etc, as required.

7. Samples

7.1 Samples shall be preserved and transported in accordance with Practice 4220 Groups B, C, or D soils. Keep the samples that are stored prior to testing in noncorrodible airtight containers at a temperature between approximately 3 and 30°C and in an area that prevents direct contact with sunlight. Disturbed samples in jars or other containers shall be stored in such a way as to prevent or minimize moisture condensation o the insides of the containers.

7.2 The water content determination should be done as soon as practicable after sampling, especially if potentially corrodible containers (such as thin-walled steel tubes, paint cans, etc or plastic sample bags are used.

8. Test Specimen

8.1 For water contents being determined in conjunct another ASTM method, the specimen mass requirement in that method shall be used if one is provided. If no minimum specimen mass is provided in that method then the values giv below shall apply. See Howard[7] for background data for t values listed.

8.2 The minimum mass of moist material selected to representative of the total sample shall be in accordance w the following:

Maximum particle size (100 % passing)	Standard Sieve Size	Recommended minimum mass of moist test specimen for water content reported to ±0.1 %	Recommended minimum mass of moist test specimen for water content reported to ±1 %
2 mm or less	No. 10	20 g	20 g[A]
4.75 mm	No. 4	100 g	20 g[A]
9.5 mm	⅜-in.	500 g	50 g
19.0 mm	¾-in.	2.5 kg	250 g
37.5 mm	1½ in.	10 kg	1 kg
75.0 mm	3-in.	50 kg	5 kg

[A] To be representative not less than 20 g shall be used.

8.2.1 The minimum mass used may have to be increased to obtain the needed significant digits for the mass of water when reporting water contents to the nearest 0.1 % or as indicated in 12.1.2.

[5] *Annual Book of ASTM Standards*, Vol 04.09.
[6] *Annual Book of ASTM Standards*, Vol 14.02.

[7] Howard, A. K., "Minimum Test Specimen Mass for Moisture C ter-mination", *Geotechnical Testing Journal*, A.S.T.M., Vol. 12, No. 1, M 9, pp. 39-44.

8.3 Using a test specimen smaller than the minimum indicated in 8.2 requires discretion, though it may be adequate for the purposes of the test. Any specimen used not meeting these requirements shall be noted on the test data forms or test data sheets.

8.4 When working with a small (less than 200g) specimen containing a relatively large gravel particle, it is appropriate not to include this particle in the test specimen. However, any discarded material shall be described and noted on the test data forms or test data sheets.

8.5 For those samples consisting entirely of intact rock, the minimum specimen mass shall be 500 g. Representative portions of the sample may be broken into smaller particles, depending on the sample's size, the container and balance being used and to facilitate drying to constant mass, see 10.4. Specimen sizes as small as 200 g may be tested if water contents of only two significant digits are acceptable.

9. Test Specimen Selection

9.1 When the test specimen is a portion of a larger amount of material, the specimen must be selected to be representative of the water condition of the entire amount of material. The manner in which the test specimen is selected depends on the purpose and application of the test, type of material being tested, the water condition, and the type of sample (from another test, bag, block, and the likes.)

9.2 For disturbed samples such as trimmings, bag samples, and the like, obtain the test specimen by one of the following methods (listed in order of preference):

9.2.1 If the material is such that it can be manipulated and handled without significant moisture loss and segregation, the material should be mixed thoroughly and then select a representative portion using a scoop of a size that no more than a few scoopfuls are required to obtain the proper size of specimen defined in 8.2.

9.2.2 If the material is such that it cannot be thoroughly mixed or mixed and sampled by a scoop, form a stockpile of the material, mixing as much as possible. Take at least five portions of material at random locations using a sampling tube, shovel, scoop, trowel, or similar device appropriate to the maximum particle size present in the material. Combine all the portions for the test specimen.

9.2.3 If the material or conditions are such that a stockpile cannot be formed, take as many portions of the material as practical, using random locations that will best represent the moisture condition. Combine all the portions for the test specimen.

9.3 Intact samples such as block, tube, split barrel, and the like, obtain the test specimen by one of the following methods depending on the purpose and potential use of the sample.

9.3.1 Using a knife, wire saw, or other sharp cutting device, trim the outside portion of the sample a sufficient distance to see if the material is layered and to remove material that appears more dry or more wet than the main portion of the sample. If the existence of layering is questionable, slice the sample in half. If the material is layered, see 9.3.3.

9.3.2 If the material is not layered, obtain the specimen meeting the mass requirements in 8.2 by: (1) taking all or one-half of the interval being tested; (2) trimming a representative slice from the interval being tested; or (3) trimming the exposed surface of one-half or from the interval being tested.

NOTE 4—Migration of moisture in some cohesionless soils may require that the full section be sampled.

9.3.3 If a layered material (or more than one material type is encountered), select an average specimen, or individual specimens, or both. Specimens must be properly identified as to location, or what they represent, and appropriate remarks entered on the test data forms or test data sheets.

10. Procedure

10.1 Determine and record the mass of the clean and dry specimen container (and its lid, if used).

10.2 Select representative test specimens in accordance with Section 9.

10.3 Place the moist test specimen in the container and, if used, set the lid securely in position. Determine the mass of the container and moist material using a balance (see 6.2) selected on the basis of the specimen mass. Record this value.

NOTE 5—To prevent mixing of specimens and yielding of incorrect results, all containers, and lids if used, should be numbered and the container numbers shall be recorded on the laboratory data sheets. The lid numbers should match the container numbers to eliminate confusion.

NOTE 6—To assist in the oven-drying of large test specimens, they should be placed in containers having a large surface area (such as pans) and the material broken up into smaller aggregations.

10.4 Remove the lid (if used) and place the container with moist material in the drying oven. Dry the material to a constant mass. Maintain the drying oven at 110 ± 5°C unless otherwise specified (see 1.4). The time required to obtain constant mass will vary depending on the type of material, size of specimen, oven type and capacity, and other factors. The influence of these factors generally can be established by good judgment, and experience with the materials being tested and the apparatus being used.

NOTE 7—In most cases, drying a test specimen overnight (about 12 to 16 h) is sufficient. In cases where there is doubt concerning the adequacy of drying, drying should be continued until the change in mass after two successive periods (greater than 1 h) of drying is an insignificant amount (less than about 0.1 %). Specimens of sand may often be dried to constant mass in a period of about 4 h, when a forced-draft oven is used.

NOTE 8—Since some dry materials may absorb moisture from moist specimens, dried specimens should be removed before placing moist specimens in the same oven. However, this would not be applicable if the previously dried specimens will remain in the drying oven for an additional time period of about 16 h.

10.5 After the material has dried to constant mass remove the container from the oven (and replace the lid if used). Allow the material and container to cool to room temperature or until the container can be handled comfortably with bare hands and the operation of the balance will not be affected by convection currents and/or its being heated. Determine the mass of the container and oven-dried material using the same type/capacity balance used in 10.3. Record this value. Tight fitting lids shall be used if it appears that the specimen is absorbing moisture from the air prior to determination of its dry mass.

NOTE 9—Cooling in a desiccator is acceptable in place of tight fitting lids since it greatly reduces absorption of moisture from the atmosphere during cooling especially for containers without tight fitting lids.

11. Calculation

11.1 Calculate the water content of the material as follows:

$$w = [(M_{cws} - M_{cs})/(M_{cs} - M_c)] \times 100 = \frac{M_w}{M_s} \times 100 \quad (1)$$

where:

w = water content, %,
M_{cws} = mass of container and wet specimen, g,
M_{cs} = mass of container and oven dry specimen, g,
M_c = mass of container, g,
M_w = mass of water ($M_w = M_{cws} - M_{cds}$), g, and
M_s = mass of solid particles ($M_s = M_{cds} - M_c$), g.

12. Report

12.1 Test data forms or test data sheets shall include the following:

12.1.1 Identification of the sample (material) being tested, such as boring number, sample number, test number, container number etc.

12.1.2 Water content of the specimen to the nearest 1 % or 0.1 %, as appropriate based on the minimum sample used. If this method is used in concert with another method, the water content of the specimen should be reported to the value required by the test method for which the water content is being determined. Refer to Guide D 6026 for guidance concerning significant digits, especially if the value obtained from this test method is to be used to calculate other relationships such as unit weight or density. For instance, if it is desired to express dry unit weight to the nearest 0.1 lbf/f^3(0.02 kN/m^3), it may be necessary to use a balance with a greater readability or use a larger specimen mass to obtain the required significant digits the mass of water so that the water content can be determined to the required significant digits. Also, the significant digits in Guide D 6026 may need to be increased when calculating phase relationships requiring four significant digits.

12.1.3 Indicate if test specimen had a mass less than the minimum indicated in 8.2.

12.1.4 Indicate if test specimen contained more than one material type (layered, etc.).

12.1.5 Indicate the temperature of drying if different from 110 ± 5°C.

12.1.6 Indicate if any material (size and amount) excluded from the test specimen.

12.2 When reporting water content in tables, figures, etc., any data not meeting the requirements of this test method shall be noted, such as not meeting the mass, balance, or temperature requirements or a portion of the material is excluded from the test specimen.

13. Precision and Bias

13.1 *Statement on Bias*—There is no accepted reference value for this test method; therefore, bias cannot be determined.

13.2 *Statements on Precision*:

13.2.1 *Single-Operator Precision (Repeatability)*—The single-operator coefficient of variation has been found to be 2.7 percent. Therefore, results of two properly conducted tests by the same operator with the same equipment should not be considered suspect unless they differ by more than 7.8 percent of their mean.[8]

13.2.2 *Multilaboratory Precision (Reproducibility)*[9]—The multilaboratory coefficient of variation has been found to be 5.0 percent. Therefore, results of two properly conducted tests by different operators using different equipment should not be considered suspect unless they differ by more than 14.0 percent of their mean.

14. Keywords

14.1 consistency; index property; laboratory; m[illegible] analysis; moisture content; soil aggregate; water content

[8] These numbers represent the (1s) and (d2s) limits as described in Practice C 670.

[9] These numbers represent the (1s %) and (d2s %) limits as described in Practice C 670.

SUMMARY OF CHANGES

Committee D-18 has identified the location of selected changes to this standard since the last issue. (D 2216-92) that may impact the use of this standard.

(*1*) Title was changed to emphasize that mass is the basis for the standard.

(*2*) Section 1.1 was revised to clarify "similar materials".

(*3*) New 1.2 was added to explain a limitation in scope. The other sections were renumbered as appropriate.

(*4*) An information reference was included in 1.5.

(*5*) An information reference was included in 1.6

(*6*) A new ASTM referenced document was included in 2.1.

(*7*) New Footnotes 2, 3, and 5 were added and identified. Other footnotes were renumbered where necessary for sequential identification.

(*8*) Information concerning balances was added in 6.2

(*9*) Section 6.3 was revised to clarify the use of close-fitting lids, and a reference to Note 8 was added.

(*10*) In 6.4, "anhydrous calcium phosphate" was changed to "anyhydrous calcium sulfate" to correct an error and to agree with Note 3.

(*11*) A typo in 8.1 was corrected from "before" to "below" and a footnoted reference was added for information.

(*12*) A portion of 8.2 was deleted for clarity.

(*13*) A new 8.2.1 was added to clarify minimum mass requirements.

(*14*) Sections 8.3, 8.4, 9.3.3, and 12.1 were changed to substitute "test data form/sheet" for "report".

(*15*) Footnote seven was identified.

(*16*) Section 9.2.1 was revised to improve clarity and i[illegible].

(*17*) The word "possible" was changed to "practical" in 9.2.3

(*18*) Section 9.3.1 and 9.3.2 were revised to improve clarity and for practicality.
(*19*) A reference to Guide D 6026 was added in 12.1.2.
(*20*) Footnotes 8 and 9 were added to 13.2.1 and 13.2.2, respectively. These were inadvertently omitted from the 1992 version. These explanations provide clarity and information to the user.
(*21*) A Summary of Changes was added to reflect D-18's policy.

D

APPENDIX D

MOISTURE CONTENT TEST RESULTS

MOISTURE CONTENT DATA SHEET
ASTM METHOD D2216-98

SOIL/SEDIMENT BENCH-SCALE TREATABILITY STUDY
SITE 8 FEASIBILITY STUDY
NCBC GULFPORT – GULFPORT, MISSISSIPPI
CTO O143

DATE: September 5, 2000

SAMPLE ID: SOIL ASH

MEDIUM: 01

OBSERVATIONS: Fine-Grained Silty Sand, Black in Color, Uniform Distribution, Non-Cohesive.

DRYING OVEN:

Temperature (°C)	Time In (9-5-00)	Time Out (9-6-00)
223°F = 106°C	16:13	7:58

* Sample allowed to cool for 45 minutes before weighing

WEIGHTS:

Item	Weight (grams)
Wet Material + Drying Dish	538
Drying Dish	12
Wet Material	526
Dry Material + Drying Dish	500
Drying Dish	12
Dry Material	488

MOISTURE CONTENT:

$$\text{Percent Moisture} = \frac{(\text{Weight Wet Material} - \text{Weight Dry Material})}{\text{Weight Wet Material}} \times 100$$

$$\text{Percent Moisture} = \frac{(526\text{ g} - 488\text{ g})}{526\text{ g}} \times 100 = 7.2\ \%$$

MOISTURE CONTENT DATA SHEET
ASTM METHOD D2216-98

SOIL/SEDIMENT BENCH-SCALE TREATABILITY STUDY
SITE 8 FEASIBILITY STUDY
NCBC GULFPORT – GULFPORT, MISSISSIPPI
CTO 0143

DATE: September 18, 2000

SAMPLE ID: ONBASE SEDIMENT

MEDIUM: 01

OBSERVATIONS: Mixture of sandy soil and organically-decayed matter that has settled in the ditch. Free Water Visible, Dark Brown Color, Cohesive.

DRYING OVEN:

Temperature (°C)	Time In (9-15-00)	Time Out (9-17-00)
223°F = 106°C	12:30	12:20

* Sample allowed to cool for 45 minutes before weighing

WEIGHTS:

Item	Weight (grams)
Wet Material + Drying Dish	550
Drying Dish	12
Wet Material	538
Dry Material + Drying Dish	421
Drying Dish	12
Dry Material	409

MOISTURE CONTENT:

$$\text{Percent Moisture} = \frac{(\text{Weight Wet Material} - \text{Weight Dry Material})}{\text{Weight Wet Material}} \times 100$$

$$\text{Percent Moisture} = \frac{(538\text{ g} - 409\text{ g})}{538\text{ g}} \times 100 = 24\ \%$$

MOISTURE CONTENT DATA SHEET
ASTM METHOD D2216-98

SOIL/SEDIMENT BENCH-SCALE TREATABILITY STUDY
SITE 8 FEASIBILITY STUDY
NCBC GULFPORT – GULFPORT, MISSISSIPPI
CTO O143

DATE: September 5, 2000

SAMPLE ID: OFF-BASE SED

MEDIUM: 01

OBSERVATIONS: Silty Clay, Fine Grained, Cohesive, Light Brown in Color.

DRYING OVEN:

Temperature (°C)	Time In (9-5-00)	Time Out (9-6-00)
223°F = 106°C	16:13	7:58

* Sample allowed to cool for 45 minutes before weighing

WEIGHTS:

Item	Weight (grams)
Wet Material + Drying Dish	510
Drying Dish	12
Wet Material	498
Dry Material + Drying Dish	429
Drying Dish	12
Dry Material	417

MOISTURE CONTENT:

$$\text{Percent Moisture} = \frac{(\text{Weight Wet Material} - \text{Weight Dry Material})}{\text{Weight Wet Material}} \times 100$$

$$\text{Percent Moisture} = \frac{(498\text{ g} - 417\text{ g})}{498\text{ g}} \times 100 = 16.3\ \%$$

MOISTURE CONTENT DATA SHEET
ASTM METHOD D2216-98

SOIL/SEDIMENT BENCH-SCALE TREATABILITY STUDY
SITE 8 FEASIBILITY STUDY
NCBC GULFPORT – GULFPORT, MISSISSIPPI
CTO 0143

DATE: September 18, 2000

SAMPLE ID: MATERIALBLEND

MEDIUM: 01

OBSERVATIONS: Dark brown, fine-grained silty sand.

DRYING OVEN:

Temperature (°C)	Time In (9-15-00)	Time Out (9-17-00)
223°F = 106°C	13:45	12:20

* Sample allowed to cool for 45 minutes before weighing

WEIGHTS:

Item	Weight (grams)
Wet Material + Drying Dish	525
Drying Dish	12
Wet Material	513
Dry Material + Drying Dish	431
Drying Dish	12
Dry Material	419

MOISTURE CONTENT:

$$\text{Percent Moisture} = \frac{(\text{Weight Wet Material} - \text{Weight Dry Material})}{\text{Weight Wet Material}} \times 100$$

$$\text{Percent Moisture} = \frac{(513\text{ g} - 419\text{ g})}{513\text{ g}} \times 100 = 18.3\ \%$$

E

APPENDIX E

FIRST-TIER TESTING LABORATORY DATA SHEETS

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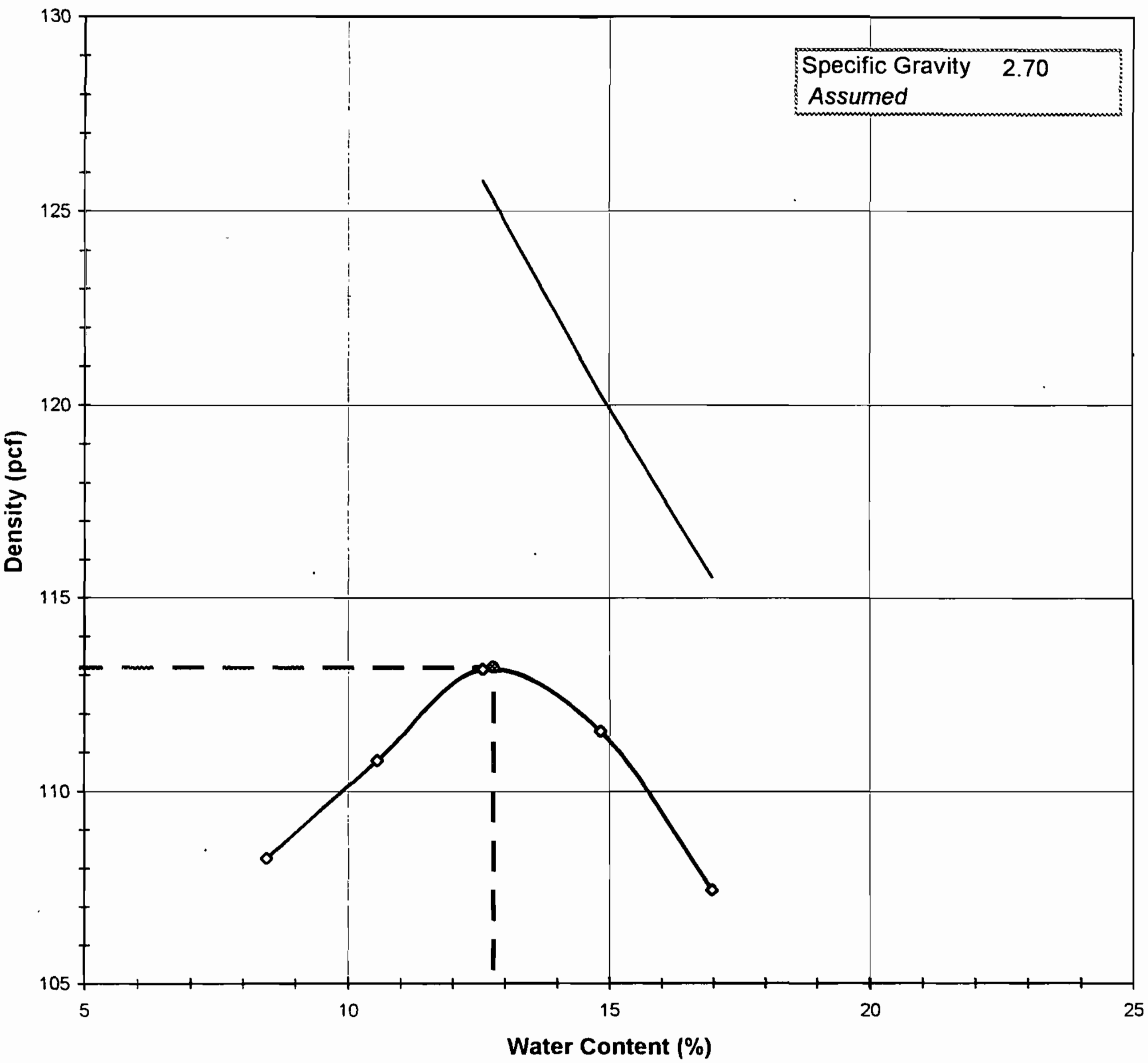
MOISTURE DENSITY RELATIONSHIP

ASTM D698-91 SOP-S12

Client	TETRA TECH NUS	Boring No.	NA
Client Reference	GULFPORT N0567	Depth (ft)	NA
Project No.	00248-01	Sample No.	GFP-08-MB-01-01
Lab ID	00248-01.001	Test Method	**STANDARD**

Visual Description BROWN SILTY CLAY

Optimum Water Content	**12.8**
Maximum Dry Density	**113.2**



Tested By GU *Date* 9/20/00 *Checked By* Jcm *Date* 9-21-00

DCN.CT-S12 DATE: 6-25-98 REVISION 3

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MOISTURE - DENSITY RELATIONSHIP

ASTM D698-91 SOP-S12

Client	TETRA TECH NUS	Boring No.	NA
Client Reference	GULFPORT N0567	Depth (ft)	NA
Project No.	00248-01	Sample No.	GFP-08-MB-01-01
Lab ID	00248-01.001		

Visual Description BROWN SILTY CLAY

Total Weight of the Sample (gm)	NA
As Received Water Content(%)	NA
Assumed Specific Gravity	2.70
Percent Retained on 3/4"	NA
Percent Retained on 3/8"	NA
Percent Retained on #4	NA
Oversize Material	Not included
Procedure Used	B

TestType	STANDARD
Rammer Weight (lbs)	5.5
Rammer Drop (in)	12
Rammer Type	Mechanical
Machine ID	G774
Mold ID	G777
Mold diameter	4"
Weight of the Mold	4206
Volume of the Mold(cc)	944

Mold / Specimen

Point No.	1	2	3	4	5
Wt. of Mold & WS (gm)	5982	6059	6133	6144	6107
Wt.of Mold (gm)	4206	4206	4206	4206	4206
Wt. of WS	1776	1853	1927	1938	1901
Mold Volume (cc)	944	944	944	944	944

Moisture Content / Density

Tare Number	540	599	550	573	607
Wt. of Tare & WS (gm)	502.00	481.20	491.90	486.70	508.70
Wt. of Tare & DS (gm)	469.40	443.40	446.10	434.50	446.90
Wt. of Tare (gm)	83.41	85.29	81.90	82.53	82.91
Wt. of Water (gm)	32.60	37.80	45.80	52.20	61.80
Wt. of DS (gm)	385.99	358.11	364.20	351.97	363.99

Wet Density (gm/cc)	1.88	1.96	2.04	2.05	2.01
Wet Density (pcf)	117.4	122.5	127.4	128.1	125.7
Moisture Content (%)	**8.4**	**10.6**	**12.6**	**14.8**	**17.0**
Dry Density (pcf)	**108.3**	**110.8**	**113.1**	**111.6**	**107.4**
Pocket Penetrometer (tsf) Bottom	+5	+5	+5	2.0	.05
Top	+5	+5	+5	1.5	.05
Side	NO READING	NO READING	NO READING	1.0	.5

Moisture Content (%)	12.6	14.8	17.0
Dry Unit Weight (pcf)	125.8	120.3	115.5

Tested By GU *Date* 9/20/00 *Checked By* Jcm *Date* 9-21-00

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SINGLE POINT CBR TEST

ASTM D 1883-94(SOP-S27)

Client	TETRA TECH NUS	Boring No.	NA
Client Reference	GULFPORT N0567	Depth(ft.)	NA
Project No.	00248-01	Sample No.	GFP-08-MB-01-01
Lab ID	00248-01.001	Visual Description	BROWN SILTY CLAY

		Density Measurement	**Before Soaking**	**After Soaking**	
Test Type	STANDARD	Wt. Mold & WS (gm.)	11417	11385	
Molding Method	C	Wt. WS (gm.)	4143	4111	
Mold ID	A	Sample Volume (cc)	2124	2093	
Wt. of Mold (gm.)	7274	Wet Density (gm./cc)	1.95	1.94	
Mold Volume (cc)	2124	Wet Density (pcf)	121.7	120.8	
					Top 1"
Surcharge (lbs.)	**20**	Tare No.	673	535	578
Piston Area (in^2)	3	Wt. of T+WS (gm.)	517.9	1415.2	510.1
Sample Height	4.58	Wt. of T+DS (gm.)	442.9	1202.7	440.3
		Wt of Tare (gm.)	73.02	101.04	84.55
Sample Conditions	Soaked	Moisture Content	20.3%	19.3%	19.6%
Blows per Layer	**56**				
		Dry Density (pcf)	**101.2**	**101.2**	
		Dry Density (gm./cc)	**1.62**	**1.62**	

Piston Displacement (in.)	**Load (lbs.)**	**Penetration Stress (psi.)**	**Swell Measurement**		
0	0	0.0	Elapsed Time (hrs)	Dial Gauge (Div)	Percent Swell
0.025	2	0.7			
0.050	8	2.7			
0.075	17	5.7			
0.100	23	7.7	0	500	0.00%
0.125	30	10.0	0.1	500	0.00%
0.150	38	12.7	0.3	500	0.00%
0.175	43	14.3	1.5	482	-0.39%
0.200	53	17.7	21.3	460	-0.87%
0.250	70	23.3	24.8	436	-1.40%
0.300	85	28.3	49.8	434	-1.44%
0.350	102	34.0	74.8	433.5	-1.45%
0.400	119	39.7	96	433	-1.46%
0.450	136	45.3	**1Division**	**0.001**	**in.**
0.500	151	50.3			
0.550	167	55.7			
.600	184	61.3			

Tested By *JP/GU* *Date* *9/18/00* *Checked By* TM *Date* 9-27-00

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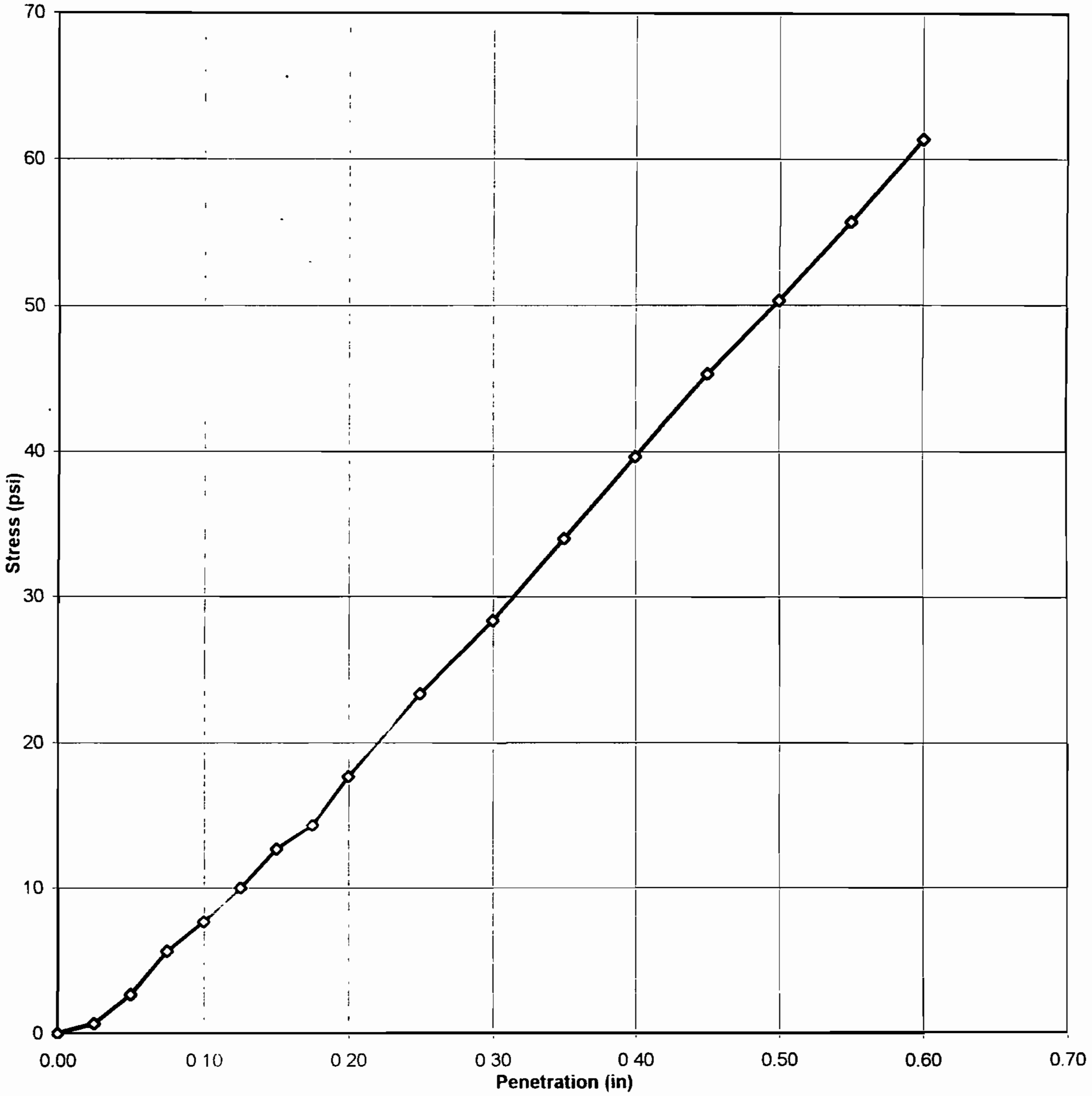
SINGLE POINT CBR TEST
ASTM D 1883-94(SOP-S27)

Client	TETRA TECH NUS	Boring No.	NA
Client Reference	GULFPORT N0567	Depth(ft.)	NA
Project No.	00248-01	Sample No.	GFP-08-MB-01-01
Lab ID	00248-01.001	Visual Description	BROWN SILTY CLAY

Penetration Stress vs. Penetration

CBR VALUE (0.1") **0.77 %**
CBR VALUE (0.2") **1.18 %**



Tested By *JP/GU* *Date* *9/18/00* *Checked By* TM *Date* 9-27-00

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SINGLE POINT CBR TEST

ASTM D 1883-94(SOP-S27)

Client	TETRA TECH NUS	Boring No.	NA
Client Reference	GULF PORT N0567	Depth(ft.)	NA
Project No.	00248-01	Sample No.	GFP-08-MB-01-01
Lab ID	00248-01.001	Visual Description	BROWN SILTY CLAY

Test Type	STANDARD
Molding Method	C
Mold ID	B
Wt. of Mold (gm.)	7320
Mold Volume (cc)	2124
Surcharge (lbs.)	**20**
Piston Area (in^2)	3
Sample Height	4.58
Sample Conditions	Soaked
Blows per Layer	**25**

Density Measurement	Before Soaking	After Soaking	Top 1"
Wt. Mold & WS (gm.)	11443	11554	
Wt. WS (gm.)	4123	4234	
Sample Volume (cc)	2124	2124	
Wet Density (gm./cc)	1.94	1.99	
Wet Density (pcf)	121.1	124.4	
Tare No.	1745	2339	580
Wt. of T+WS (gm.)	596.8	1229.9	622.7
Wt. of T+DS (gm.)	538.2	1088.2	549.9
Wt of Tare (gm.)	82.09	99.32	84.64
Moisture Content	12.8%	14.3%	15.6%
Dry Density (pcf)	**107.3**	**108.8**	
Dry Density (gm./cc)	**1.72**	**1.74**	

Piston Displacement (in.)	Load (lbs.)	Penetration Stress (psi.)
0	0	0.0
0.025	101	33.7
0.050	181	60.3
0.075	285	95.0
0.100	345	115.0
0.125	380	126.7
0.150	427	142.3
0.175	506	168.7
0.200	556	185.3
0.250	631	210.3
0.300	720	240.0
0.350	767	255.7
0.400	847	282.3
0.450	930	310.0
0.500	1023	341.0
0.550	1076	358.7
0.600	1159	386.3

Swell Measurement

Elapsed Time (hrs)	Dial Gauge (Div)	Percent Swell
0	500	0.00%
0.1	500	0.00%
0.2	501	0.02%
0.8	501	0.02%
1.8	501	0.02%
20.3	501	0.02%
44.3	501	0.02%
68.3	501	0.02%
92.3	501	0.02%
1Division	**0.001**	**in.**

Tested By *GU/JP* *Date* *9/21/00* *Checked By* TM *Date* 9-27-00

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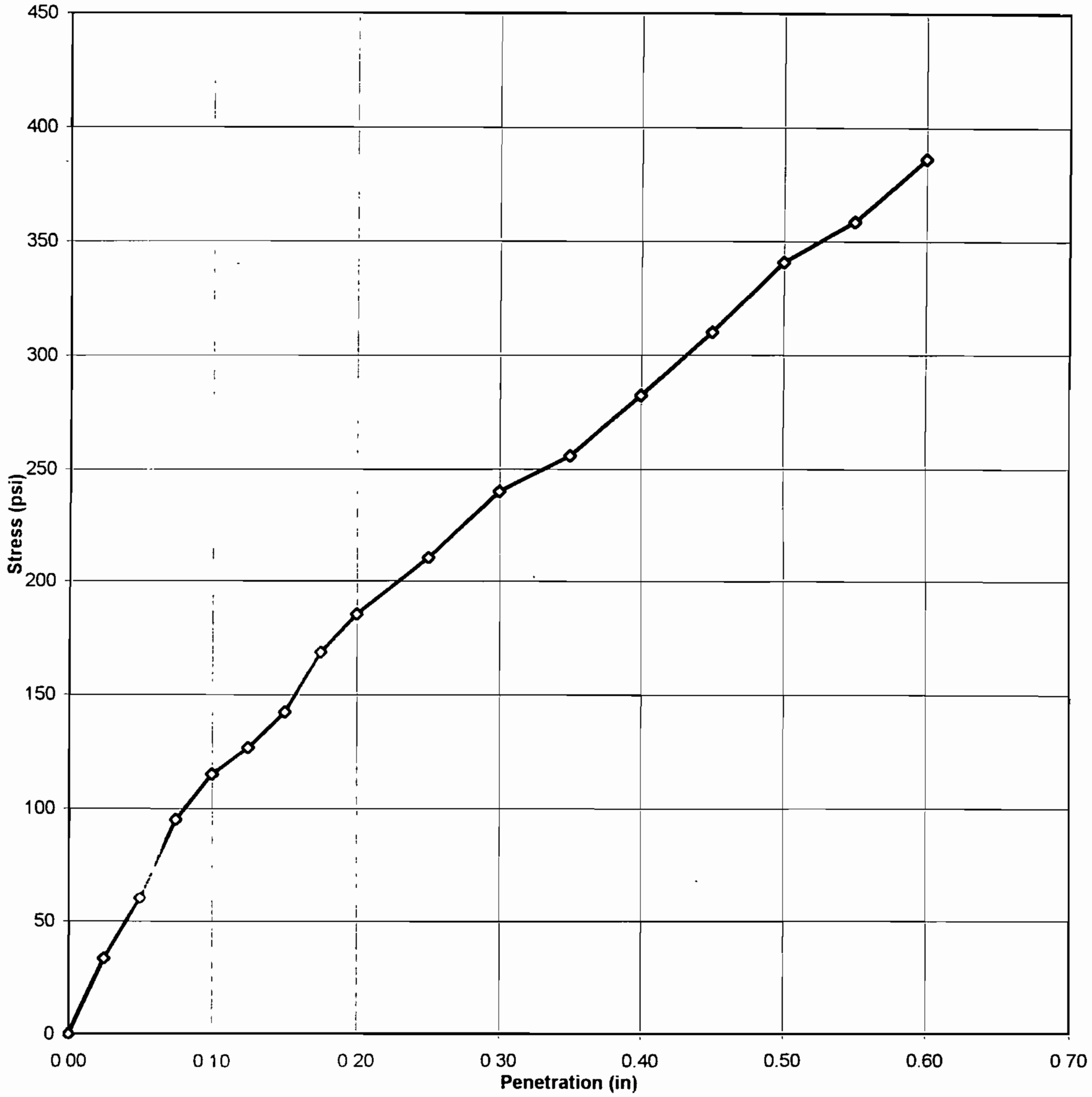
SINGLE POINT CBR TEST
ASTM D 1883-94(SOP-S27)

Client	TETRA TECH NUS	Boring No.	NA
Client Reference	GULF PORT N0567	Depth(ft.)	NA
Project No.	00248-01	Sample No.	GFP-08-MB-01-01
Lab ID	00248-01.001	Visual Description	BROWN SILTY CLAY

Penetration Stress vs. Penetration

CBR VALUE (0.1")	**11.50 %**
CBR VALUE (0.2")	**12.36 %**



Tested By *GU/JP* *Date* *9/21/00* *Checked By* TM *Date* 9-27-00

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F

APPENDIX F

SECOND-TIER TESTING LABORATORY DATA SHEETS

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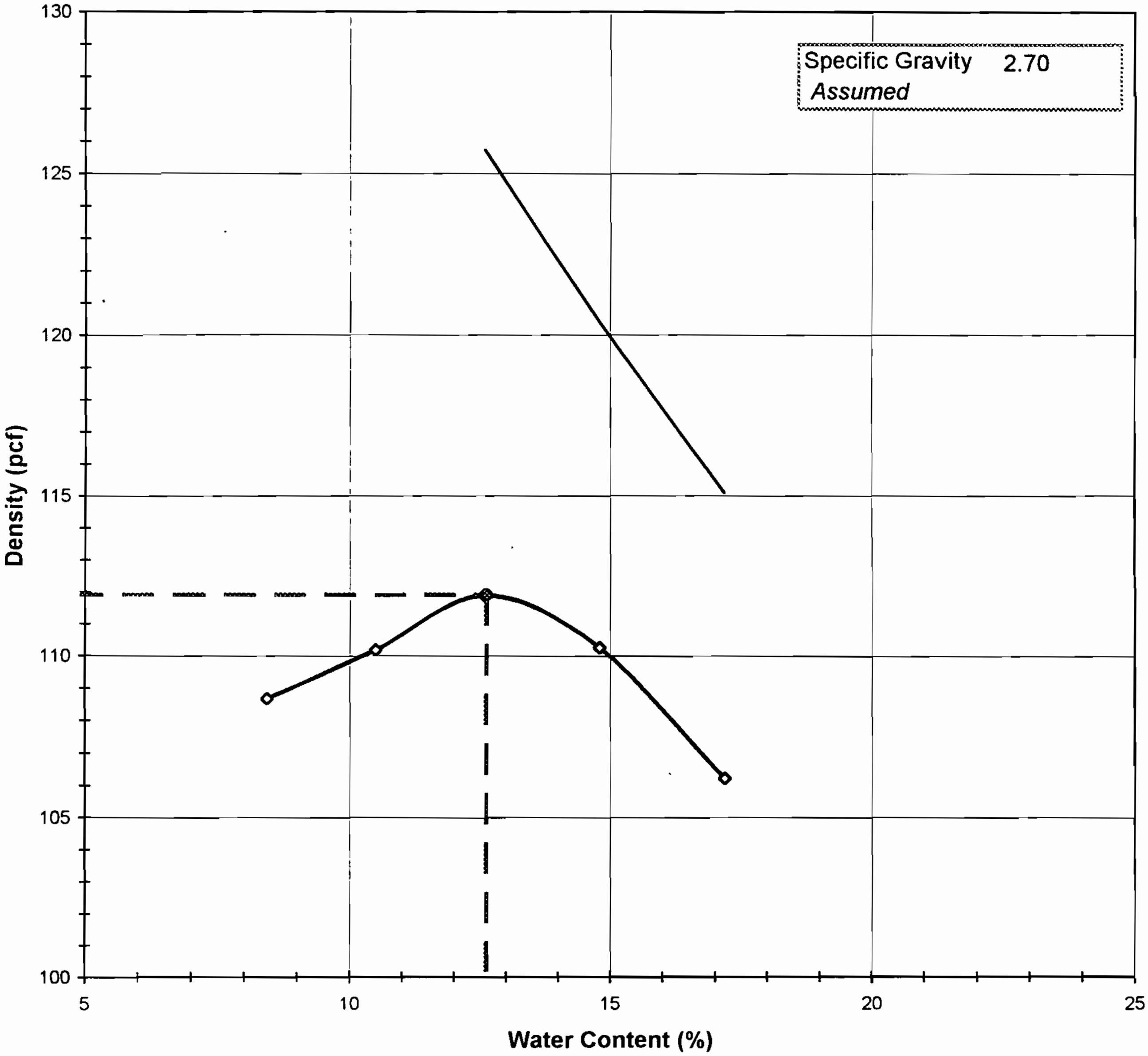
MOISTURE DENSITY RELATIONSHIP

ASTM D698-91 SOP-S12

Client	TETRA TECH NUS	Boring No.	GFP-08-MB-02
Client Reference	GULFPORT N0567	Depth (ft)	NA
Project No.	00248-02	Sample No.	FA-05
Lab ID	00248-02.001	Test Method	**STANDARD**

Visual Description BROWN CLAY,ROCK FRAGMENTS, AND FLYASH

Optimum Water Content	**12.6**
Maximum Dry Density	**111.9**



Tested By JP *Date* 9/27/00 *Checked By* Jm *Date* 10.11.00

DCN:CT-S12 DATE: 6-25-98 REVISION 3

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MOISTURE - DENSITY RELATIONSHIP

ASTM D698-91 SOP-S12

Client	TETRA TECH NUS	Boring No.	GFP-08-MB-02
Client Reference	GULFPORT N0567	Depth (ft)	NA
Project No.	00248-02	Sample No.	FA-05
Lab ID	00248-02.001		

Visual Description BROWN CLAY,ROCK FRAGMENTS, AND FLYASH

Total Weight of the Sample (gm)	NA
As Received Water Content(%)	NA
Assumed Specific Gravity	2.70
Percent Retained on 3/4"	NA
Percent Retained on 3/8"	NA
Percent Retained on #4	NA
Oversize Material	Not included
Procedure Used	B

TestType	**STANDARD**
Rammer Weight (lbs)	5.5
Rammer Drop (in)	12
Rammer Type	Mechanical
Machine ID	G774
Mold ID	G777
Mold diameter	4"
Weight of the Mold	4207
Volume of the Mold(cc)	944

Mold / Specimen

Point No.	**1**	**2**	**3**	**4**	**5**
Wt. of Mold & WS (gm)	5990	6049	6113	6122	6090
Wt.of Mold (gm)	4207	4207	4207	4207	4207
Wt. of WS	1783	1842	1906	1915	1883
Mold Volume (cc)	944	944	944	944	944

Moisture Content / Density

Tare Number	585	1693	596	630	1724
Wt. of Tare & WS (gm)	388.55	373.49	356.90	471.30	531.70
Wt. of Tare & DS (gm)	365.00	345.94	326.55	421.20	465.90
Wt. of Tare (gm)	85.71	83.44	85.52	82.57	82.99
Wt. of Water (gm)	23.55	27.55	30.35	50.10	65.80
Wt. of DS (gm)	279.29	262.50	241.03	338.63	382.91

Wet Density (gm/cc)	1.89	1.95	2.02	2.03	1.99
Wet Density (pcf)	117.9	121.8	126.0	126.6	124.5
Moisture Content (%)	**8.4**	**10.5**	**12.6**	**14.8**	**17.2**
Dry Density (pcf)	**108.7**	**110.2**	**111.9**	**110.3**	**106.2**
Pocket Penetrometer (tsf) TOP	**0.0**	**0.0**	**0.0**	**1.8**	**0.5**

Moisture Content (%)	12.6	14.8	17.2
Dry Unit Weight (pcf)	125.7	120.4	115.1

Tested By JP *Date* 9/27/00 *Checked By* Jm *Date* 10-11-00

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SINGLE POINT CBR TEST

ASTM D 1883-94(SOP-S27)

Client	TETRA TECH NUS	Boring No.	GFP-08-MB-02
Client Reference	GULFPORT N0567	Depth(ft.)	NA
Project No.	00248-02	Sample No.	FA 5
Lab ID	00248-02.001	Visual Description	BROWN CLAY,ROCK FRAGMENTS,& FLYASH

		Density Measurement	**Before Soaking**	**After Soaking**	
Test Type	STANDARD	Wt. Mold & WS (gm.)	11360	11325	
Molding Method	C	Wt. WS (gm.)	4182	4147	
Mold ID	C	Sample Volume (cc)	2124	2108	
Wt. of Mold (gm.)	7178	Wet Density (gm./cc)	1.97	1.96	
Mold Volume (cc)	2124	Wet Density (pcf)	122.9	122.2	
					Top 1"
Surcharge (lbs.)	**20**	Tare No.	556	1683	1739
Piston Area (in^2)	3	Wt. of T+WS (gm.)	390.1	966.4	492.6
Sample Height	4.58	Wt. of T+DS (gm.)	340.03	835	428.7
		Wt of Tare (gm.)	81.84	97.73	83.82
Sample Conditions	Soaked	Moisture Content	19.4%	17.8%	18.5%
Blows per Layer	**56**				
		Dry Density (pcf)	**102.9**	**103.7**	
		Dry Density (gm./cc)	**1.65**	**1.66**	

AS RECEIVED WATER CONTENT

Piston isplacement (in.)	**Load (lbs.)**	**Penetration Stress (psi.)**
0	0	0.0
0.025	16	5.3
0.050	23	7.7
0.075	31	10.3
0.100	36	12.0
0.125	43	14.3
0.150	51	17.0
0.175	57	19.0
0.200	63	21.0
0.250	77	25.7
0.300	90	30.0
0.350	102	34.0
0:400	117	39.0
0.450	130	43.3
0.500	145	48.3
0.550	159	53.0
0.600	174	58.0

Swell Measurement

Elapsed Time (hrs)	Dial Gauge (Div)	Percent Swell
0	500	0.00%
0.1	498	-0.04%
0.9	488	-0.26%
1.3	480	-0.44%
2.8	473	-0.59%
66.8	466	-0.74%
91.8	466	-0.74%
96	466	-0.74%

1Division 0.001 in.

Tested By GU/JP *Date* 9/29/00 *Checked By* QA *Date* 10-5-00

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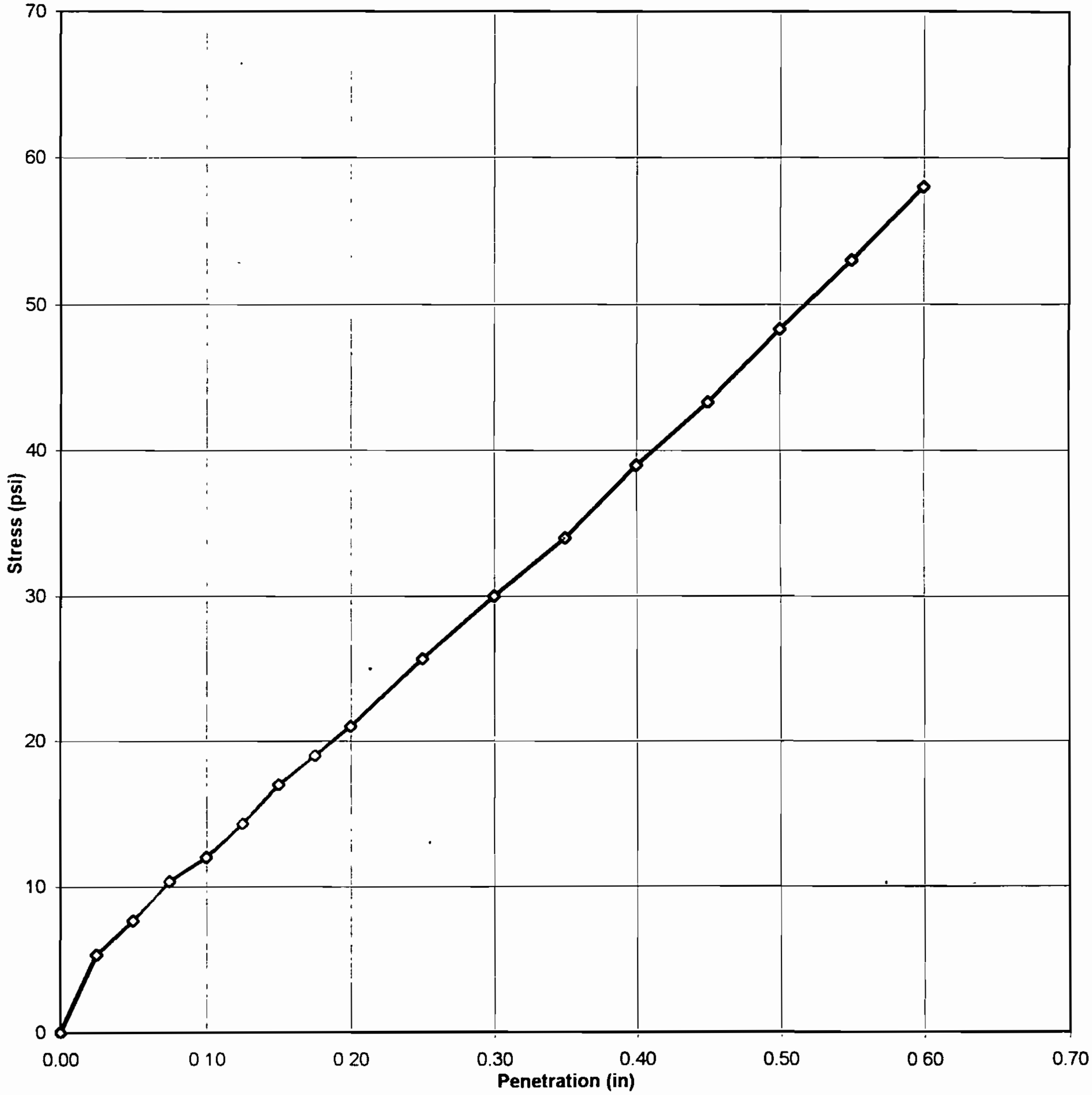
SINGLE POINT CBR TEST
ASTM D 1883-94(SOP-S27)

Client	TETRA TECH NUS	Boring No.	GFP-08-MB-02
Client Reference	GULFPORT N0567	Depth(ft.)	NA
Project No.	00248-02	Sample No.	FA 5
Lab ID	00248-02.001	Visual Description	BROWN CLAY,ROCK FRAGMENTS,& FLYASH

Penetration Stress vs. Penetration

CBR VALUE (0.1") **1.20 %**
CBR VALUE (0.2") **1.40 %**



Tested By *GU/JP* *Date* *9/29/00* *Checked By* *Date 10·5·00*

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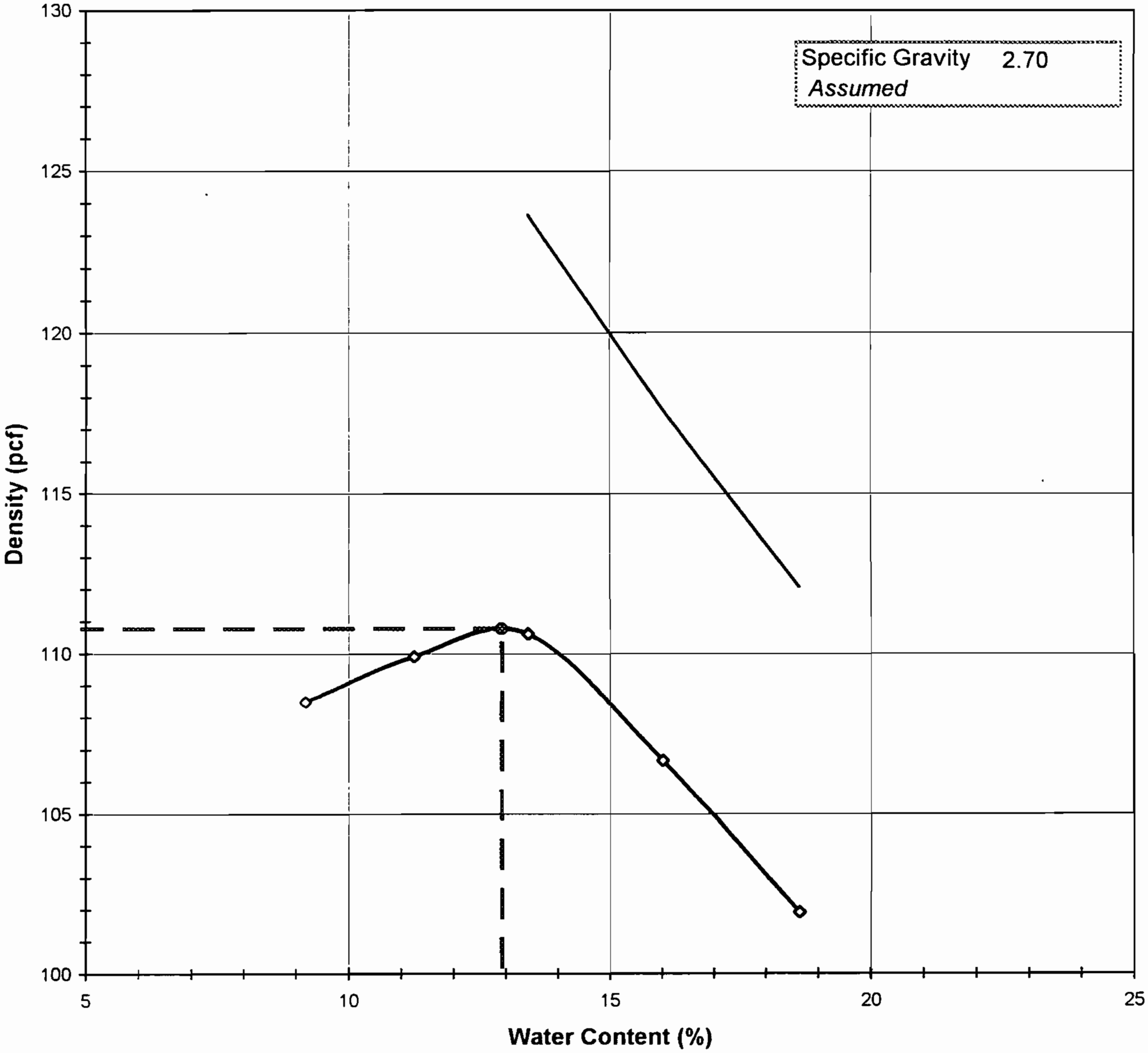
MOISTURE DENSITY RELATIONSHIP

ASTM D698-91 SOP-S12

Client	TETRA TECH NUS	Boring No.	GFP-08-MB-02
Client Reference	GULFPORT N0567	Depth (ft)	NA
Project No.	00248-02	Sample No.	FA-10
Lab ID	00248-02.002	Test Method	**STANDARD**

Visual Description BROWN SANDY CLAY AND ROCK FRAGMENTS

Optimum Water Content	**12.9**
Maximum Dry Density	**110.8**



Tested By	*JP*	*Date*	*9/27/00*	*Checked By*	JMO	*Date*	9/29/00

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MOISTURE - DENSITY RELATIONSHIP

ASTM D698-91 SOP-S12

Client	TETRA TECH NUS	Boring No.	GFP-08-MB-02
Client Reference	GULFPORT N0567	Depth (ft)	NA
Project No.	00248-02	Sample No.	FA-10
Lab ID	00248-02.002		

Visual Description BROWN SANDY CLAY AND ROCK FRAGMENTS

Total Weight of the Sample (gm)	NA
As Received Water Content(%)	NA
Assumed Specific Gravity	2.70
Percent Retained on 3/4"	NA
Percent Retained on 3/8"	NA
Percent Retained on #4	NA
Oversize Material	Not included
Procedure Used	B

TestType	STANDARD
Rammer Weight (lbs)	5.5
Rammer Drop (in)	12
Rammer Type	Manual
Machine ID	NA
Mold ID	G606
Mold diameter	4"
Weight of the Mold	4234
Volume of the Mold(cc)	944

Mold / Specimen

Point No.	1	2	3	4	5
Wt. of Mold & WS (gm)	6026	6084	6132	6106	6063
Wt.of Mold (gm)	4234	4234	4234	4234	4234
Wt. of WS	1792	1850	1898	1872	1829
Mold Volume (cc)	944	944	944	944	944

Moisture Content / Density

Tare Number	601	552	1710	551	1131A
Wt. of Tare & WS (gm)	540.50	548.70	547.40	587.80	754.00
Wt. of Tare & DS (gm)	502.30	501.50	492.40	518.30	648.80
Wt. of Tare (gm)	86.08	81.90	82.68	84.52	84.52
Wt. of Water (gm)	38.20	47.20	55.00	69.50	105.20
Wt. of DS (gm)	416.22	419.60	409.72	433.78	564.28

Wet Density (gm/cc)	1.90	1.96	2.01	1.98	1.94
Wet Density (pcf)	118.5	122.3	125.5	123.7	120.9
Moisture Content (%)	**9.2**	**11.2**	**13.4**	**16.0**	**18.6**
Dry Density (pcf)	**108.5**	**109.9**	**110.6**	**106.7**	**101.9**
Pocket Penetrometer (tsf) Top	**+5**	**+5**	**2.8**	**0.65**	**0**
Bottom	**+5**	**+5**	**3.5**	**0.75**	**0**
Side	**0**	**0**	**1.75**	**0.65**	**0**
Moisture Content (%)		13.4	16.0	18.6	
Dry Unit Weight (pcf)		123.7	117.6	112.1	

Tested By JP *Date* 9/27/00 *Checked By* JHC *Date* 9/29/00

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SINGLE POINT CBR TEST

ASTM D 1883-94(SOP-S27)

Client	TETRA TECH NUS	Boring No.	GFP-08-MB-02
Client Reference	GULFPORT N0567	Depth(ft.)	NA
Project No.	00248-02	Sample No.	FA 10
Lab ID	00248-02.002	Visual Description	BROWN CLAY,ROCK FRAGMENTS,& FLYASH

Test Type	STANDARD
Molding Method	C
Mold ID	D
Wt. of Mold (gm.)	7189
Mold Volume (cc)	2124
Surcharge (lbs.)	**20**
Piston Area (in^2)	3
Sample Height	4.58
Sample Conditions	Soaked
Blows per Layer	**56**

Density Measurement	**Before Soaking**	**After Soaking**	**Top 1"**
Wt. Mold & WS (gm.)	11351	11363	
Wt. WS (gm.)	4162	4174	
Sample Volume (cc)	2124	2124	
Wet Density (gm./cc)	1.96	1.97	
Wet Density (pcf)	122.3	122.7	
Tare No.	7	1631	731
Wt. of T+WS (gm.)	415.1	1380	485.9
Wt. of T+DS (gm.)	364.12	1191.9	424
Wt of Tare (gm.)	74.92	95.23	84.95
Moisture Content	17.6%	17.2%	18.3%
Dry Density (pcf)	**103.9**	**104.7**	
Dry Density (gm./cc)	**1.67**	**1.68**	

AS RECEIVED WATER CONTENT

Piston isplacement (in.)	**Load (lbs.)**	**Penetration Stress (psi.)**
0	0	0.0
0.025	0	0.0
0.050	12	4.0
0.075	22	7.3
0.100	30	10.0
0.125	40	13.3
0.150	50	16.7
0.175	59	19.7
0.200	69	23.0
0.250	87	29.0
0.300	106	35.3
0.350	126	42.0
0.400	146	48.7
0.450	167	55.7
0.500	189	63.0
0.550	213	71.0
0.600	233	77.7

Swell Measurement

Elapsed Time (hrs)	Dial Gauge (Div)	Percent Swell
0	500	0.00%
0.1	499	-0.02%
0.9	498	-0.04%
1.3	497	-0.07%
2.8	497	-0.07%
66.8	497	-0.07%
91.8	497	-0.07%
96	500	0.00%

1Division 0.001 in.

Tested By *GU/JP* *Date* *9/29/00* *Checked By* [signature] *Date* *10.5.00*

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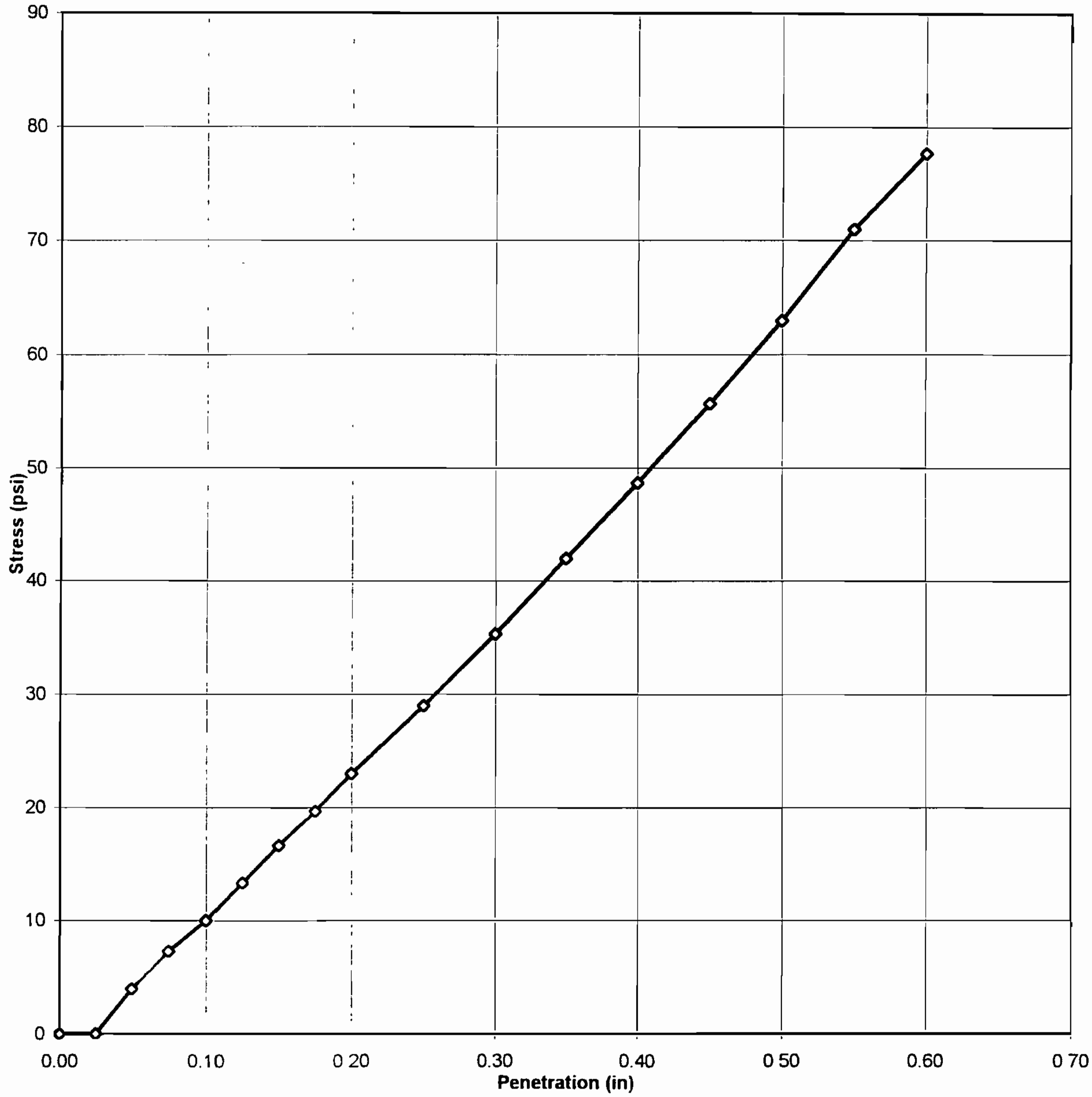
SINGLE POINT CBR TEST
ASTM D 1883-94(SOP-S27)

Client	TETRA TECH NUS	Boring No.	GFP-08-MB-02
Client Reference	GULFPORT N0567	Depth(ft.)	NA
Project No.	00248-02	Sample No.	FA 10
Lab ID	00248-02.002	Visual Description	BROWN CLAY,ROCK FRAGMENTS,& FLYASH

Penetration Stress vs. Penetration

CBR VALUE (0.1")	**1.00 %**
CBR VALUE (0.2")	**1.53 %**



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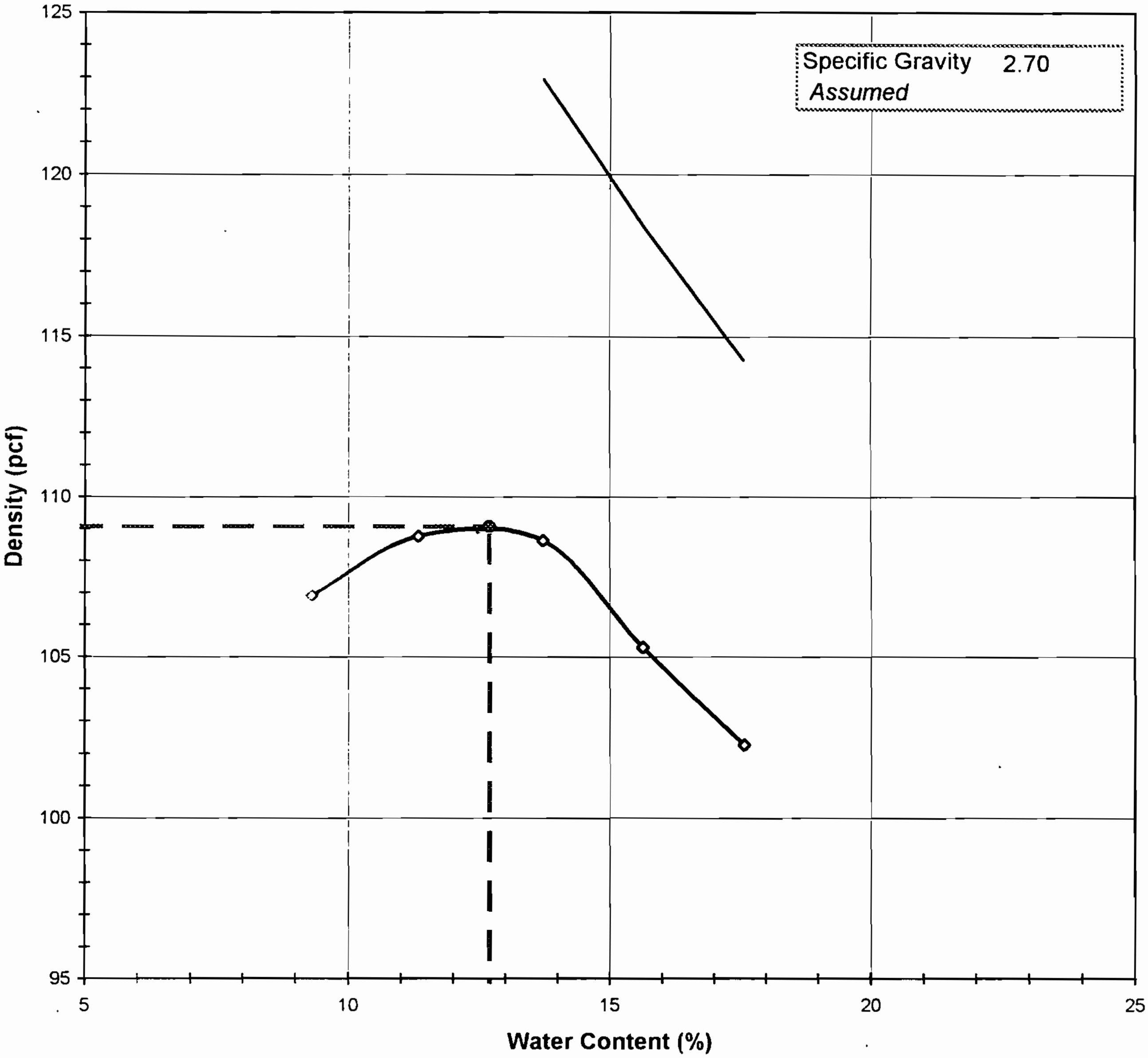
MOISTURE DENSITY RELATIONSHIP

ASTM D698-91 SOP-S12

Client	TETRA TECH NUS	Boring No.	GFP-08-MB-02
Client Reference	GULFPORT N0567	Depth (ft)	NA
Project No.	00248-02	Sample No.	FA-15
Lab ID	00248-02.003	Test Method	**STANDARD**

Visual Description BROWN CLAY, ROCK FRAGMENTS, AND FLYASH

Optimum Water Content **12.7**
Maximum Dry Density **109.1**



Tested By JP *Date* 9/27/00 *Checked By* Jcm *Date* 10-11-00

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MOISTURE - DENSITY RELATIONSHIP

ASTM D698-91 SOP-S12

Client	TETRA TECH NUS	Boring No.	GFP-08-MB-02
Client Reference	GULFPORT N0567	Depth (ft)	NA
Project No.	00248-02	Sample No.	FA-15
Lab ID	00248-02.003		

Visual Description BROWN CLAY, ROCK FRAGMENTS, AND FLYASH

Total Weight of the Sample (gm)	NA
As Received Water Content(%)	NA
Assumed Specific Gravity	2.70
Percent Retained on 3/4"	NA
Percent Retained on 3/8"	NA
Percent Retained on #4	NA
Oversize Material	Not included
Procedure Used	B

TestType	STANDARD
Rammer Weight (lbs)	5.5
Rammer Drop (in)	12
Rammer Type	Mechanical
Machine ID	G774
Mold ID	G777
Mold diameter	4"
Weight of the Mold	4207
Volume of the Mold(cc)	944

Mold / Specimen

Point No.	1	2	3	4	5
Wt. of Mold & WS (gm)	5975	6039	6076	6049	6026
Wt.of Mold (gm)	4207	4207	4207	4207	4207
Wt. of WS	1768	1832	1869	1842	1819
Mold Volume (cc)	944	944	944	944	944

Moisture Content / Density

Tare Number	616	1745	1705	594	673
Wt. of Tare & WS (gm)	393.37	444.50	417.60	522.60	462.30
Wt. of Tare & DS (gm)	367.10	407.60	377.27	462.90	404.10
Wt. of Tare (gm)	85.03	82.09	83.41	81.03	72.92
Wt. of Water (gm)	26.27	36.90	40.33	59.70	58.20
Wt. of DS (gm)	282.07	325.51	293.86	381.87	331.18

Wet Density (gm/cc)	1.87	1.94	1.98	1.95	1.93
Wet Density (pcf)	116.9	121.1	123.5	121.8	120.2
Moisture Content (%)	**9.3**	**11.3**	**13.7**	**15.6**	**17.6**
Dry Density (pcf)	**106.9**	**108.8**	**108.6**	**105.3**	**102.3**
Pocket Penetrometer (tsf) TOP	**0**	**0**	**4.0**	**1.0**	**.5**

Moisture Content (%)	13.7	15.6	17.6
Dry Unit Weight (pcf)	122.9	118.5	114.3

Tested By JP *Date* 9/27/00 *Checked By* Jcm *Date* 10-11-00

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SINGLE POINT CBR TEST

ASTM D 1883-94(SOP-S27)

Client	TETRA TECH NUS	Boring No.	GFP-08-MB-02
Client Reference	GULFPORT N0567	Depth(ft.)	NA
Project No.	00248-02	Sample No.	FA 15
Lab ID	00248-02.003	Visual Description	BROWN CLAY,ROCK FRAGMENTS,& FLYASH

		Density Measurement	**Before Soaking**	**After Soaking**	**Top 1"**
Test Type	STANDARD	Wt. Mold & WS (gm.)	11182	11206	
Molding Method	C	Wt. WS (gm.)	4108	4132	
Mold ID	E	Sample Volume (cc)	2124	2124	
Wt. of Mold (gm.)	7074	Wet Density (gm./cc)	1.93	1.95	
Mold Volume (cc)	2124	Wet Density (pcf)	120.7	121.4	
Surcharge (lbs.)	**20**	Tare No.	1712	2490	615
Piston Area (in^2)	3	Wt. of T+WS (gm.)	498.9	997.7	532.3
Sample Height	4.58	Wt. of T+DS (gm.)	439.4	874	466.9
		Wt of Tare (gm.)	82.65	98.81	84.55
Sample Conditions	Soaked	Moisture Content	16.7%	16.0%	17.1%
Blows per Layer	**56**				
		Dry Density (pcf)	**103.4**	**104.7**	
		Dry Density (gm./cc)	**1.66**	**1.68**	

AS RECEIVED WATER CONTENT

Piston isplacement (in.)	**Load (lbs.)**	**Penetration Stress (psi.)**
0	0	0.0
0.025	24	8.0
0.050	39	13.0
0.075	54	18.0
0.100	70	23.3
0.125	89	29.7
0.150	109	36.3
0.175	131	43.7
0.200	151	50.3
0.250	198	66.0
0.300	241	80.3
0.350	285	95.0
0.400	329	109.7
0.450	370	123.3
0.500	416	138.7
0.550	459	153.0
0.600	508	169.3

Swell Measurement

Elapsed Time (hrs)	Dial Gauge (Div)	Percent Swell
0	502	0.00%
0.1	502	0.00%
0.9	502	0.00%
1.3	502	0.00%
2.8	502	0.00%
66.8	502	0.00%
91.8	502	0.00%
96	502	0.00%

1Division 0.001 in.

Tested By GU/JP *Date* 9/29/00 *Checked By* [signature] *Date* 10-5-00

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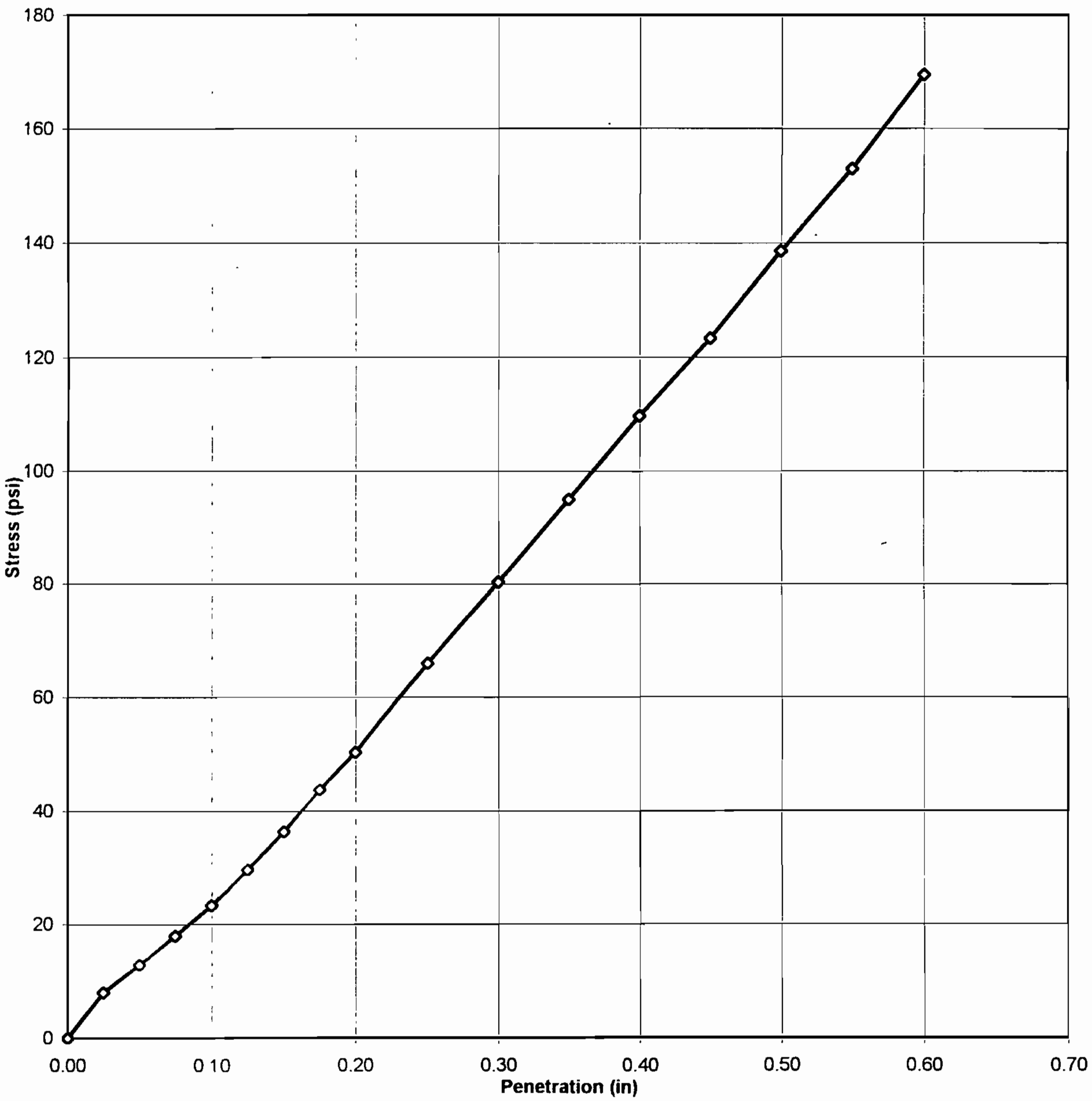
SINGLE POINT CBR TEST
ASTM D 1883-94(SOP-S27)

Client	TETRA TECH NUS	Boring No.	GFP-08-MB-02
Client Reference	GULFPORT N0567	Depth(ft.)	NA
Project No.	00248-02	Sample No.	FA 15
Lab ID	00248-02.003	Visual Description	BROWN CLAY,ROCK FRAGMENTS,& FLYASH

Penetration Stress vs. Penetration

CBR VALUE (0.1") **2.33 %**
CBR VALUE (0.2") **3.36 %**



Tested By *GU/JP* *Date* *9/29/00* *Checked By* *Date 10.5.00*

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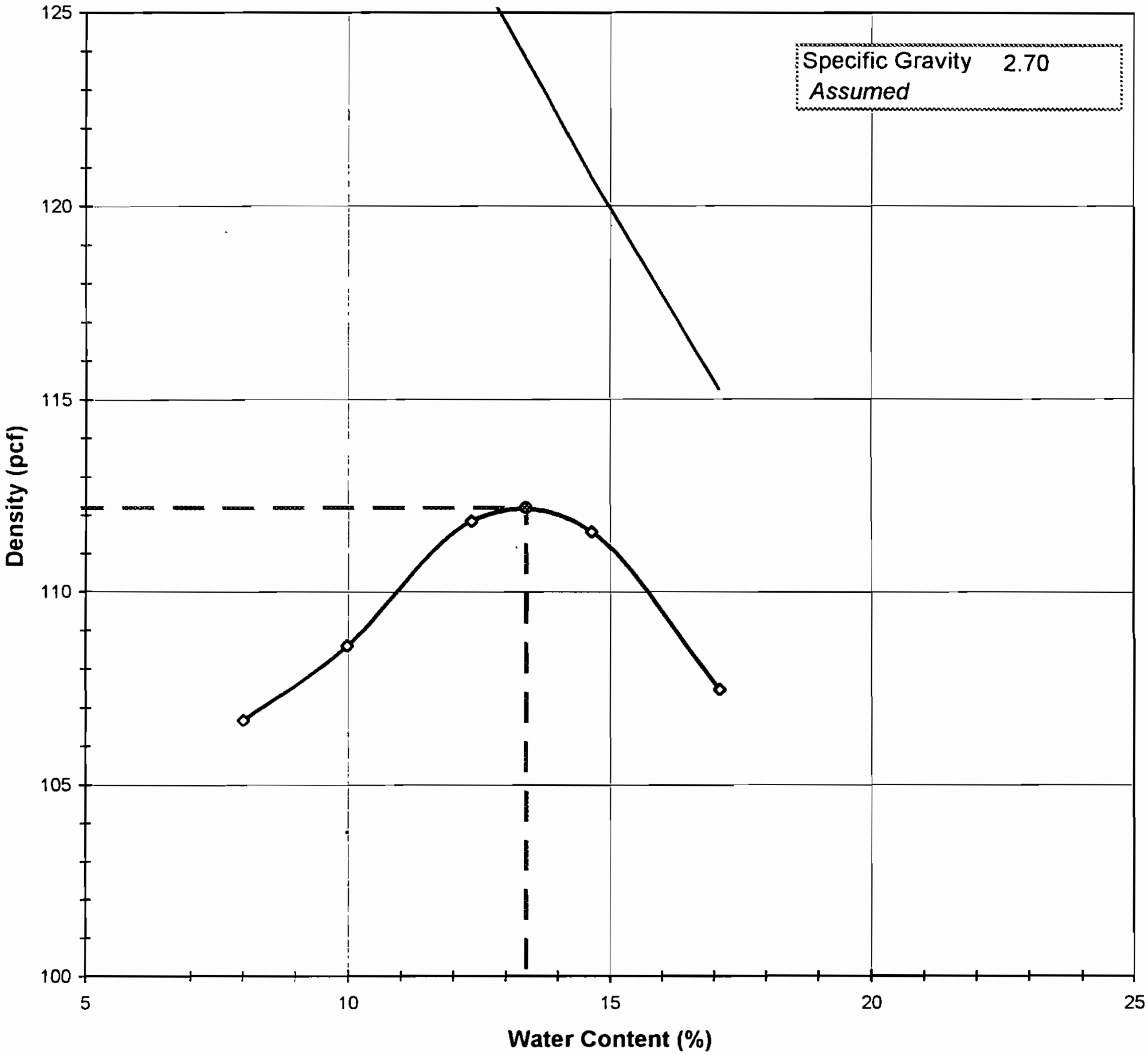
MOISTURE DENSITY RELATIONSHIP

ASTM D698-91 SOP-S12

Client	TETRA TECH NUS	Boring No.	GFP-08-MB-02
Client Reference	GULFPORT N0567	Depth (ft)	NA
Project No.	00248-02	Sample No.	PC ~~CK~~-05
Lab ID	00248-02.004	Test Method	**STANDARD**

Visual Description BROWN CLAY, ROCK FRAGMENTS, AND CEMENT ~~KILN DUST~~
PORTLAND

Optimum Water Content	**13.4**
Maximum Dry Density	**112.2**



Tested By *JP* *Date* *9/28/00* *Checked By* Jcm *Date* 10-11-00

 DCN·CT-S12 DATE. 6-25-98 REVISION 3 *C \MSOFFICE\EXCEL\PrintQ\[C414.xls]Sheet1*

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MOISTURE - DENSITY RELATIONSHIP

ASTM D698-91 SOP-S12

Client	TETRA TECH NUS	Boring No.	GFP-08-MB-02
Client Reference	GULFPORT N0567	Depth (ft)	NA
Project No.	00248-02	Sample No.	PC ~~CK~~-05
Lab ID	00248-02.004		

Visual Description BROWN CLAY, ROCK FRAGMENTS, AND PORTLAND CEMENT ~~KILN DUST~~

Total Weight of the Sample (gm)	NA
As Received Water Content(%)	NA
Assumed Specific Gravity	2.70
Percent Retained on 3/4"	NA
Percent Retained on 3/8"	NA
Percent Retained on #4	NA
Oversize Material	Not included
Procedure Used	B

TestType	STANDARD
Rammer Weight (lbs)	5.5
Rammer Drop (in)	12
Rammer Type	Mechanical
Machine ID	G774
Mold ID	G777
Mold diameter	4"
Weight of the Mold	4206
Volume of the Mold(cc)	944

Mold / Specimen

Point No.	1	2	3	4	5
Wt. of Mold & WS (gm)	5949	6013	6107	6141	6110
Wt.of Mold (gm)	4206	4206	4206	4206	4206
Wt. of WS	1743	1807	1901	1935	1904
Mold Volume (cc)	944	944	944	944	944

Moisture Content / Density

Tare Number	563	606	571	573	1692
Wt. of Tare & WS (gm)	415.80	423.00	439.90	535.90	384.43
Wt. of Tare & DS (gm)	391.08	392.36	400.80	478.00	340.37
Wt. of Tare (gm)	82.58	85.59	84.31	82.57	82.82
Wt. of Water (gm)	24.72	30.64	39.10	57.90	44.06
Wt. of DS (gm)	308.50	306.77	316.49	395.43	257.55

Wet Density (gm/cc)	1.85	1.91	2.01	2.05	2.02
Wet Density (pcf)	115.2	119.4	125.7	127.9	125.9
Moisture Content (%)	**8.0**	**10.0**	**12.4**	**14.6**	**17.1**
Dry Density (pcf)	**106.7**	**108.6**	**111.8**	**111.6**	**107.5**
Pocket Penetrometer (tsf) TOP	**0**	**0**	**0**	**3.5**	**1.5**

Moisture Content (%)	12.4	14.6	17.1
Dry Unit Weight (pcf)	126.3	120.7	115.2

Tested By JP *Date* 9/28/00 *Checked By* Jem *Date* 10-11-00

 DCN CT-S12 DATE. 6-25-98 REVISION 3 C:\MSOFFICE\EXCEL\PrintQ\[C414.xls]Sheet1

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DCN: CT-S27
DATE: 12/16/96
REVISION 1

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SINGLE POINT CBR TEST

ASTM D 1883-94(SOP-S27)

Client	TETRA TECH NUS	Boring No.	GFP-08-MB-02
Client Reference	GULFPORT N0567	Depth(ft.)	NA
Project No.	00248-02	Sample No.	PC ~~CK~~05
Lab ID	00248-02.004	Visual Description	BROWN CLAY, & ROCK FRAGMENTS, & PORTLAND CEMENT ~~KILN DUST~~

		Density Measurement	Before Soaking	After Soaking	
Test Type	STANDARD	Wt. Mold & WS (gm.)	11518	13032	
Molding Method	C	Wt. WS (gm.)	4246	5760	
Mold ID	A	Sample Volume (cc)	2124	2123	
Wt. of Mold (gm.)	7272	Wet Density (gm./cc)	2.00	2.71	
Mold Volume (cc)	2124	Wet Density (pcf)	124.7	169.3	
					Top 1"
Surcharge (lbs.)	**20**	Tare No.	629	1667	865
Piston Area (in^2)	3	Wt. of T+WS (gm.)	406.2	1244.8	704.7
Sample Height	4.58	Wt. of T+DS (gm.)	355.31	1072.9	611.4
		Wt of Tare (gm.)	86.69	95.49	102.04
Sample Conditions	Soaked	Moisture Content	18.9%	17.6%	18.3%
Blows per Layer	**56**				
		Dry Density (pcf)	**104.9**	**143.9**	
		Dry Density (gm./cc)	**1.68**	**2.31**	

AS RECEIVED WATER CONTENT

Piston isplacement (in.)	Load (lbs.)	Penetration Stress (psi.)
0	0	0.0
0.025	475	158.3
0.050	690	230.0
0.075	885	295.0
0.100	1070	356.7
0.125	1240	413.3
0.150	1395	465.0
0.175	1560	520.0
0.200	1700	566.7
0.250	1990	663.3
0.300	2250	750.0
0.350	2515	838.3
0.400	2775	925.0
0.450	3065	1021.7
0.500	3345	1115.0
0.550	3645	1215.0
0.600	3950	1316.7

Swell Measurement

Elapsed Time (hrs)	Dial Gauge (Div)	Percent Swell
0	500	0.00%
0.1	500	0.00%
0.3	499	-0.02%
1	497	-0.07%
18.1	497	-0.07%
42.1	497	-0.07%
67.1	497	-0.07%
89.1	497	-0.07%
96	497	-0.07%
1Division	**0.001**	**in.**

Tested By JP/GU *Date* 10/2/00 *Checked By* *Date* 10.9.00

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DCN. CT-S27
DATE. 12/16/96
REVISION 1

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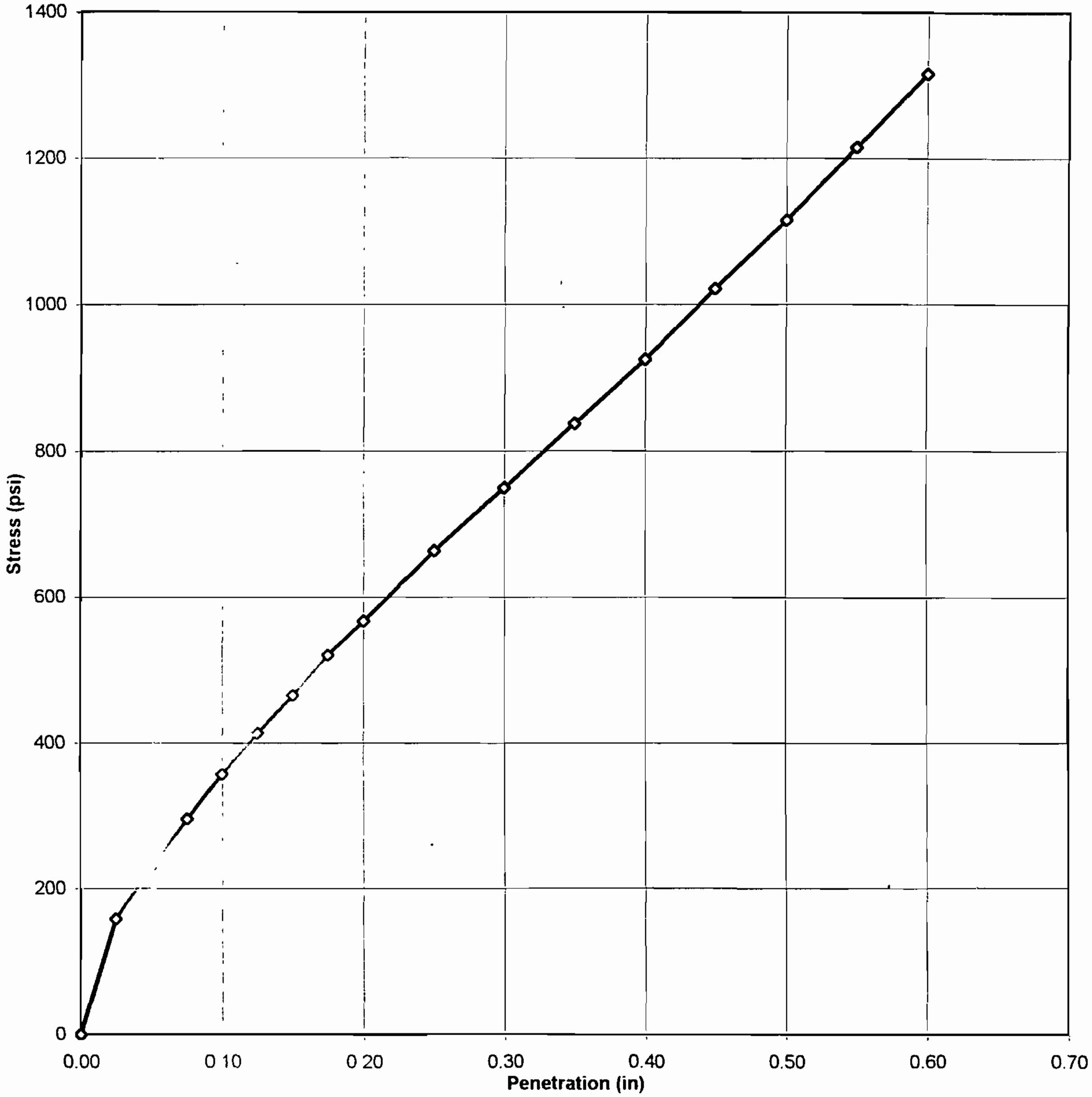
SINGLE POINT CBR TEST
ASTM D 1883-94(SOP-S27)

Client	TETRA TECH NUS	Boring No.	GFP-08-MB-02
Client Reference	GULFPORT N0567	Depth(ft.)	NA
Project No.	00248-02	Sample No.	PC ~~CK~~05
Lab ID	00248-02.004	Visual Description	BROWN CLAY, & ROCK FRAGMENTS, & PORTLAND CEMENT ~~KILN DUST~~

Penetration Stress vs. Penetration

CBR VALUE (0.1") **35.67 %**
CBR VALUE (0.2") **37.78 %**



Tested By *JP/GU* *Date* *10/2/00* *Checked By* *Date 10·2·00*

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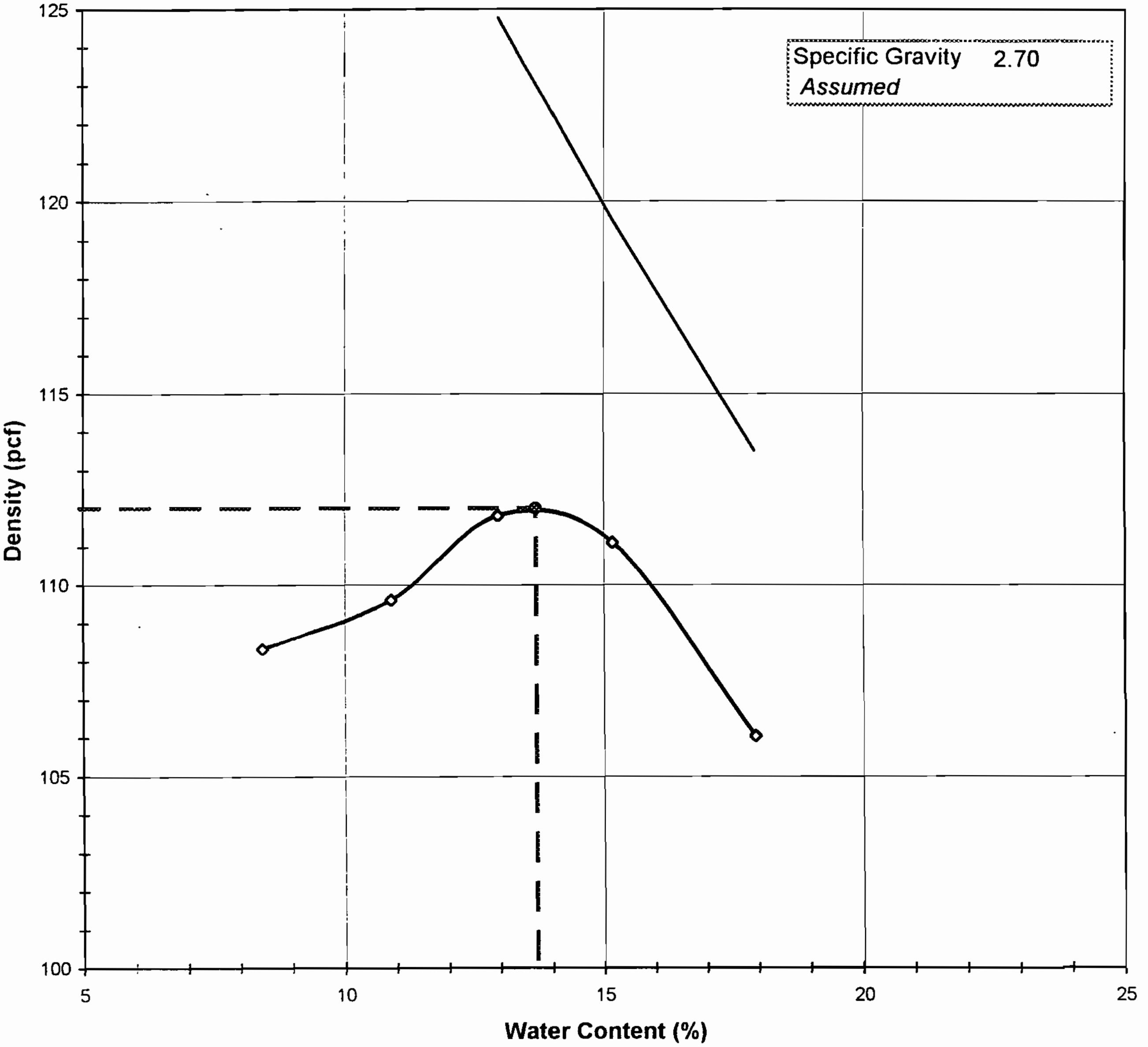
MOISTURE DENSITY RELATIONSHIP

ASTM D698-91 SOP-S12

Client	TETRA TECH NUS	Boring No.	GFP-08-MB-02
Client Reference	GULFPORT N0567	Depth (ft)	NA
Project No.	00248-02	Sample No.	PC ~~CK~~-10
Lab ID	00248-02.005	Test Method	**STANDARD**

Visual Description BROWN CLAY, ROCK FRAGMENTS, AND PORTLAND CEMENT ~~KILN DUST~~

Optimum Water Content	**13.7**
Maximum Dry Density	**112.0**



Tested By JP *Date* 9/28/00 *Checked By* Jm *Date* 10-11-00

 DCN CT-S12 DATE 6-25-98 REVISION 3 C:\MSOFFICE\EXCEL\PrintQ\[C415.xls]Sheet1

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MOISTURE - DENSITY RELATIONSHIP

ASTM D698-91 SOP-S12

Client	TETRA TECH NUS	Boring No.	GFP-08-MB-02
Client Reference	GULFPORT N0567	Depth (ft)	NA
Project No.	00248-02	Sample No.	PC ~~CK~~-10
Lab ID	00248-02.005		

Visual Description BROWN CLAY, ROCK FRAGMENTS, AND PORTLAND CEMENT ~~KILN DUST~~

Total Weight of the Sample (gm)	NA
As Received Water Content(%)	NA
Assumed Specific Gravity	2.70
Percent Retained on 3/4"	NA
Percent Retained on 3/8"	NA
Percent Retained on #4	NA
Oversize Material	Not included
Procedure Used	B

TestType	STANDARD
Rammer Weight (lbs)	5.5
Rammer Drop (in)	12
Rammer Type	Mechanical
Machine ID	G774
Mold ID	G777
Mold diameter	4"
Weight of the Mold	4206
Volume of the Mold(cc)	944

Mold / Specimen

Point No.	1	2	3	4	5
Wt. of Mold & WS (gm)	5983	6045	6117	6142	6098
Wt.of Mold (gm)	4206	4206	4206	4206	4206
Wt. of WS	1777	1839	1911	1936	1892
Mold Volume (cc)	944	944	944	944	944

Moisture Content / Density

Tare Number	566	574	630	592	607
Wt. of Tare & WS (gm)	372.54	414.70	426.80	563.80	478.70
Wt. of Tare & DS (gm)	350.17	382.16	387.28	500.30	418.50
Wt. of Tare (gm)	84.97	83.77	82.60	81.68	82.90
Wt. of Water (gm)	22.37	32.54	39.52	63.50	60.20
Wt. of DS (gm)	265.20	298.39	304.68	418.62	335.60

Wet Density (gm/cc)	1.88	1.95	2.02	2.05	2.00
Wet Density (pcf)	117.5	121.6	126.3	128.0	125.1
Moisture Content (%)	**8.4**	**10.9**	**13.0**	**15.2**	**17.9**
Dry Density (pcf)	**108.3**	**109.6**	**111.8**	**111.1**	**106.0**
Pocket Penetrometer (tsf) TOP	**0**	**0**	**0**	**2.75**	**.75**

Moisture Content (%)	13.0	15.2	17.9
Dry Unit Weight (pcf)	124.8	119.5	113.5

Tested By JP *Date* 9/28/00 *Checked By* Jm *Date* 10-11-00

 DCN CT-S12 DATE. 6-25-98 REVISION 3 C:\MSOFFICE\EXCEL\PrintQ\[C415.xls]Sheet1

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DCN: CT-S27
DATE. 12/16/96
REVISION 1

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SINGLE POINT CBR TEST
ASTM D 1883-94(SOP-S27)

Client	TETRA TECH NUS	Boring No.	GFP-08-MB-02
Client Reference	GULFPORT N0567	Depth(ft.)	NA
Project No.	00248-02	Sample No.	PC~~CK~~10
Lab ID	00248-02.005	Visual Description	BROWN CLAY, & ROCK FRAGMENTS, & PORTLAND CEMENT ~~KILN DUST~~

		Density Measurement	**Before Soaking**	**After Soaking**	**Top 1"**
Test Type	STANDARD	Wt. Mold & WS (gm.)	11620	13169	
Molding Method	C	Wt. WS (gm.)	4301	5850	
Mold ID	B	Sample Volume (cc)	2124	2121	
Wt. of Mold (gm.)	7319	Wet Density (gm./cc)	2.02	2.76	
Mold Volume (cc)	2124	Wet Density (pcf)	126.4	172.1	
Surcharge (lbs.)	**20**	Tare No.	554	2329	2353
Piston Area (in^2)	3	Wt. of T+WS (gm.)	266.28	1387.3	372.78
Sample Height	4 58	Wt. of T+DS (gm.)	239.08	1208.2	336.69
		Wt of Tare (gm.)	81.52	102.85	100.56
Sample Conditions	Soaked	Moisture Content	17.3%	16.2%	15.3%
Blows per Layer	**56**				
		Dry Density (pcf)	**107.8**	**148.1**	
		Dry Density (gm./cc)	**1.73**	**2.37**	

AS RECEIVED WATER CONTENT

Piston isplacement (in.)	**Load (lbs.)**	**Penetration Stress (psi.)**
0	0	0.0
0.025	1065	355.0
0.050	1865	621.7
0.075	2545	848.3
0.100	3160	1053.3
0.125	3720	1240.0
0.150	4250	1416.7
0.180	4840	1613.3
0.200	5215	1738.3
0.250	6130	2043.3
0.300	6955	2318.3
0.350	7745	2581.7
0.400	8550	2850.0
0.450	9345	3115.0
0.500	10120	3373.3
0.550	10865	3621.7
0.600	11665	3888.3

Swell Measurement

Elapsed Time (hrs)	Dial Gauge (Div)	Percent Swell
0	499	0.00%
0.1	499	0.00%
0.3	497	-0.13%
1	496	-0.20%
18.1	497	-0.13%
42.1	497	-0.13%
67.1	497	-0.13%
89.1	497	-0.13%
96	497	-0.13%
1Division	**0.003**	**in.**

Tested By *JP/GU* *Date* *10/2/00* *Checked By* SL *Date* *10.9.00*

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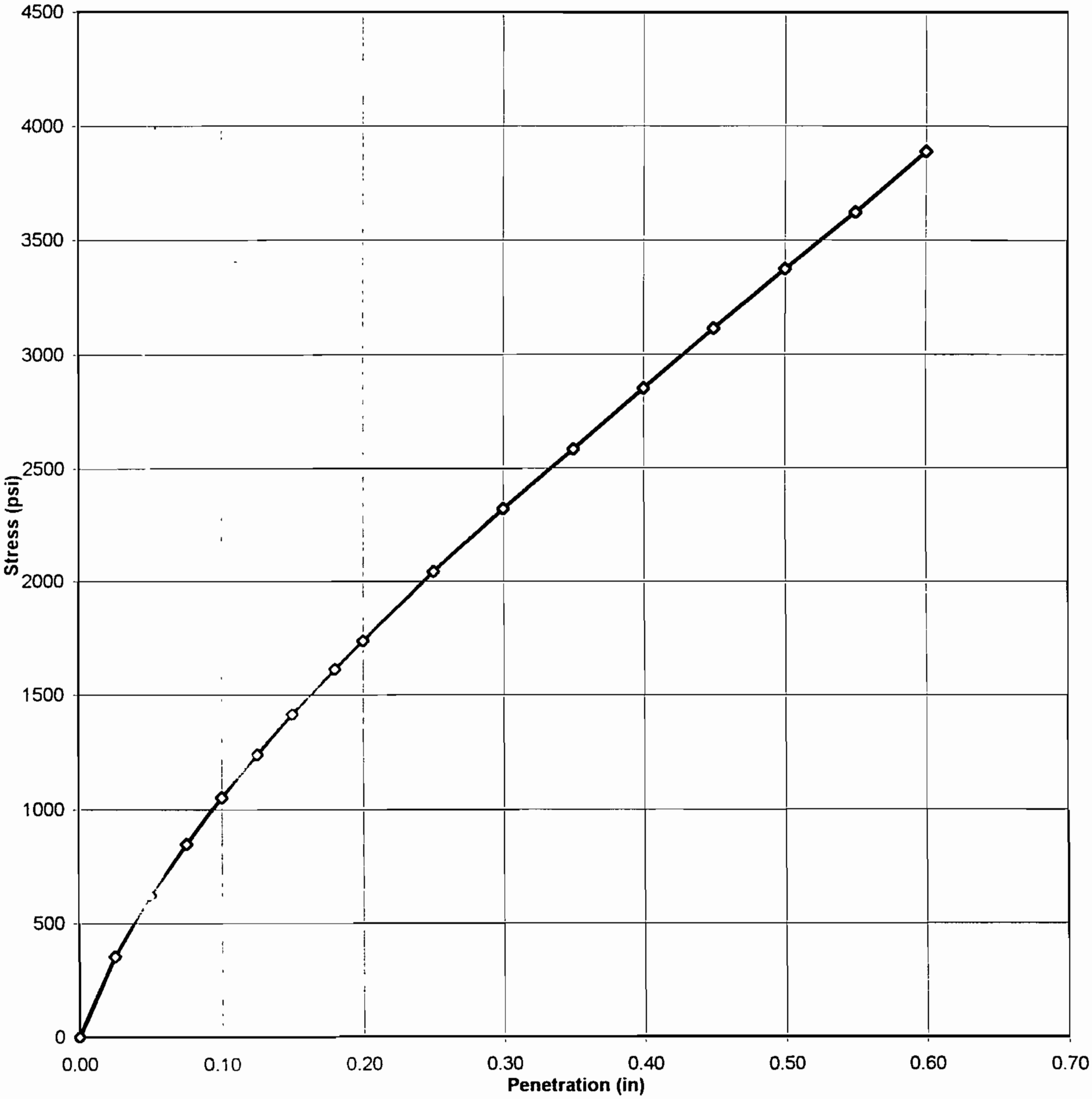
SINGLE POINT CBR TEST
ASTM D 1883-94(SOP-S27)

Client	TETRA TECH NUS	Boring No.	GFP-08-MB-02
Client Reference	GULFPORT N0567	Depth(ft.)	NA
Project No.	00248-02	Sample No.	PC ~~CK~~10
Lab ID	00248-02.005	Visual Description	BROWN CLAY, & ROCK FRAGMENTS, & PORTLAND CEMENT ~~KILN DUST~~

Penetration Stress vs. Penetration

CBR VALUE (0.1") **105.33 %**
CBR VALUE (0.2") **115.89 %**



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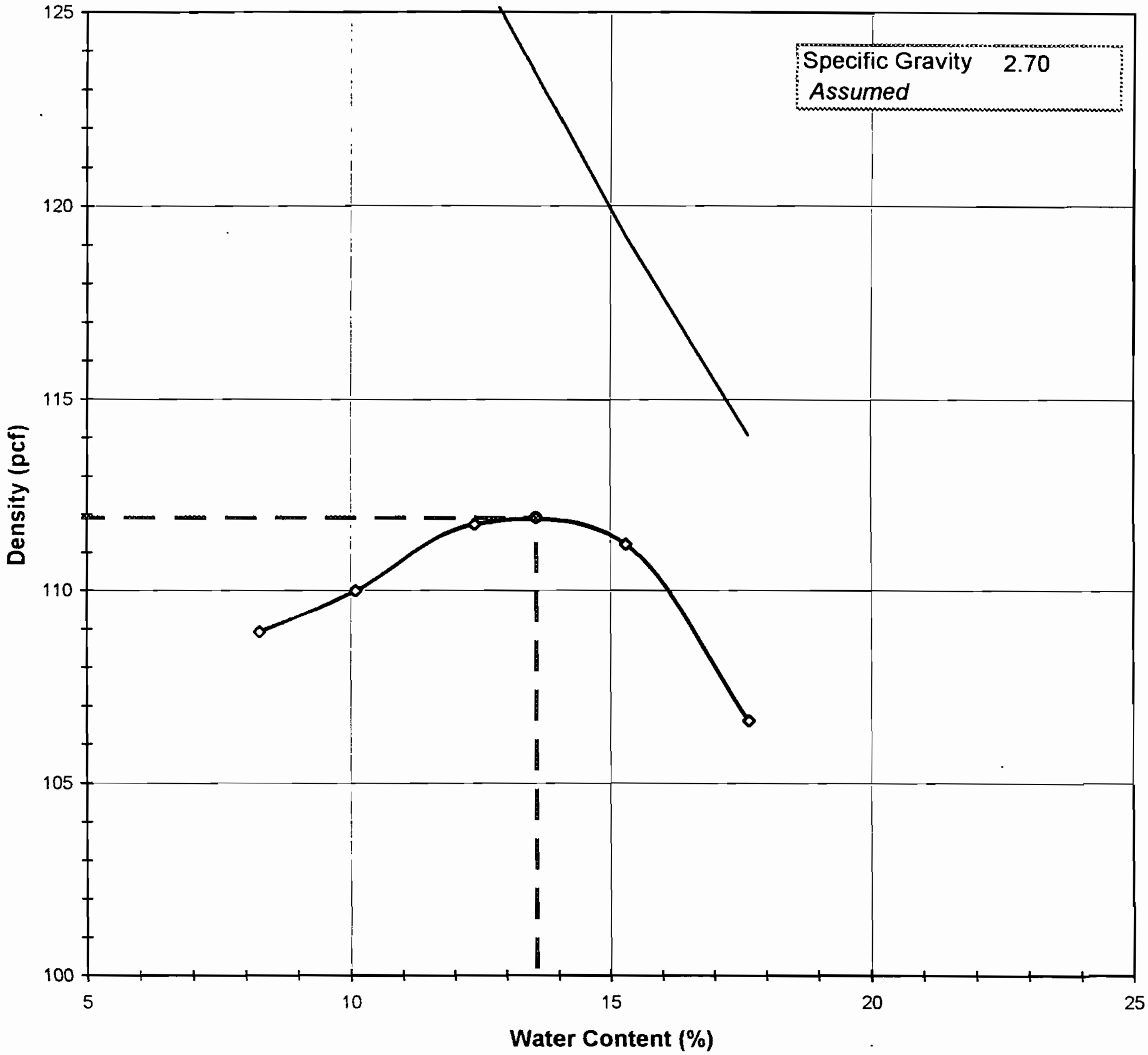
MOISTURE DENSITY RELATIONSHIP

ASTM D698-91 SOP-S12

Client	TETRA TECH NUS	Boring No.	GFP-08-MB-02
Client Reference	GULFPORT N0567	Depth (ft)	NA
Project No.	00248-02	Sample No.	PC ~~CK~~-15
Lab ID	00248-02.006	Test Method	**STANDARD**

Visual Description BROWN CLAY, ROCK FRAGMENTS, AND PORTLAND CEMENT ~~KILN DUST~~

Optimum Water Content	**13.6**
Maximum Dry Density	**111.9**



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MOISTURE - DENSITY RELATIONSHIP

ASTM D698-91 SOP-S12

Client	TETRA TECH NUS	Boring No.	GFP-08-MB-02
Client Reference	GULFPORT N0567	Depth (ft)	NA
Project No.	00248-02	Sample No.	PC ~~CK~~-15
Lab ID	00248-02.006		

Visual Description BROWN CLAY, ROCK FRAGMENTS, AND PORTLAND CEMENT ~~KILN DUST~~

Total Weight of the Sample (gm)	NA
As Received Water Content(%)	NA
Assumed Specific Gravity	2.70
Percent Retained on 3/4"	NA
Percent Retained on 3/8"	NA
Percent Retained on #4	NA
Oversize Material	Not included
Procedure Used	B

TestType	STANDARD
Rammer Weight (lbs)	5.5
Rammer Drop (in)	12
Rammer Type	Mechanical
Machine ID	G774
Mold ID	G777
Mold diameter	4"
Weight of the Mold	4206
Volume of the Mold(cc)	944

Mold / Specimen

Point No.	**1**	**2**	**3**	**4**	**5**
Wt. of Mold & WS (gm)	5990	6038	6106	6146	6104
Wt.of Mold (gm)	4206	4206	4206	4206	4206
Wt. of WS	1784	1832	1900	1940	1898
Mold Volume (cc)	944	944	944	944	944

Moisture Content / Density

Tare Number	540	785	550	688	555
Wt. of Tare & WS (gm)	398.42	409.50	430.30	433.20	436.50
Wt. of Tare & DS (gm)	374.37	379.77	391.88	386.60	383.27
Wt. of Tare (gm)	83.42	85.61	81.86	82.12	82.06
Wt. of Water (gm)	24.05	29.73	38.42	46.60	53.23
Wt. of DS (gm)	290.95	294.16	310.02	304.48	301.21

Wet Density (gm/cc)	1.89	1.94	2.01	2.06	2.01
Wet Density (pcf)	117.9	121.1	125.6	128.2	125.5
Moisture Content (%)	**8.3**	**10.1**	**12.4**	**15.3**	**17.7**
Dry Density (pcf)	**108.9**	**110.0**	**111.7**	**111.2**	**106.6**
Pocket Penetrometer (tsf) TOP	**0**	**0**	**0**	**0**	**1.25**

Moisture Content (%)	12.4	15.3	17.7
Dry Unit Weight (pcf)	126.2	119.2	114.1

Tested By JP *Date* 9/28/00 *Checked By* Jem *Date* 10-11-00

DCN:CT-S12 DATE 6-25-98 REVISION 3

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DCN CT-S27
DATE. 12/16/96
REVISION: 1

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SINGLE POINT CBR TEST

ASTM D 1883-94(SOP-S27)

Client	TETRA TECH NUS	Boring No.	GFP-08-MB-02
Client Reference	GULFPORT N0567	Depth(ft.)	NA
Project No.	00248-02	Sample No.	PC ~~CK~~15
Lab ID	00248-02.006	Visual Description	BROWN CLAY, & ROCK FRAGMENTS, & PORTLAND CEMENT ~~KILN DUST~~

		Density Measurement	Before Soaking	After Soaking	
Test Type	STANDARD	Wt. Mold & WS (gm.)	11473	13081	
Molding Method	C	Wt. WS (gm.)	4386	5994	
Mold ID	F	Sample Volume (cc)	2124	2123	
Wt. of Mold (gm.)	7087	Wet Density (gm./cc)	2.06	2.82	
Mold Volume (cc)	2124	Wet Density (pcf)	128.9	176.2	
					Top 1"
Surcharge (lbs.)	**20**	Tare No.	Z10	2499	2346
Piston Area (in^2)	3	Wt. of T+WS (gm.)	388.44	1403.7	528.8
Sample Height	4.58	Wt. of T+DS (gm.)	344.15	1222.1	472.7
		Wt of Tare (gm.)	85.93	96.4	100.21
Sample Conditions	Soaked	Moisture Content	17.2%	16.1%	15.1%
Blows per Layer	**56**				
		Dry Density (pcf)	**110.0**	**151.7**	
		Dry Density (gm./cc)	**1.76**	**2.43**	

AS RECEIVED WATER CONTENT

Piston isplacement (in.)	Load (lbs.)	Penetration Stress (psi.)	Swell Measurement: Elapsed Time (hrs)	Dial Gauge (Div)	Percent Swell
0	0	0.0			
0.020	960	320.0			
0.050	2200	733.3			
0.075	3625	1208.3			
0.100	4745	1581.7	0	487	0.00%
0.125	5690	1896.7	0.2	486	-0.02%
0.150	6590	2196.7	0.9	485	-0.04%
0.175	7400	2466.7	1.3	486	-0.02%
0.200	8100	2700.0	18	487	0.00%
0.250	9475	3158.3	42	487.5	0.01%
0.300	10650	3550.0	67	487.5	0.01%
0.350	11870	3956.7	89	488	0.02%
0.400	12950	4316.7	96	488	0.02%
0.450	14120	4706.7	**1Division**	**0.001**	**in.**
0.500	15150	5050.0			
0.550	16295	5431.7			
0.600	17345	5781.7			

Tested By *JP/GU* *Date* *10/2/00* *Checked By* [signature] *Date* 10.9.00

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DCN	CT-S27
DATE	12/16/96
REVISION.	1

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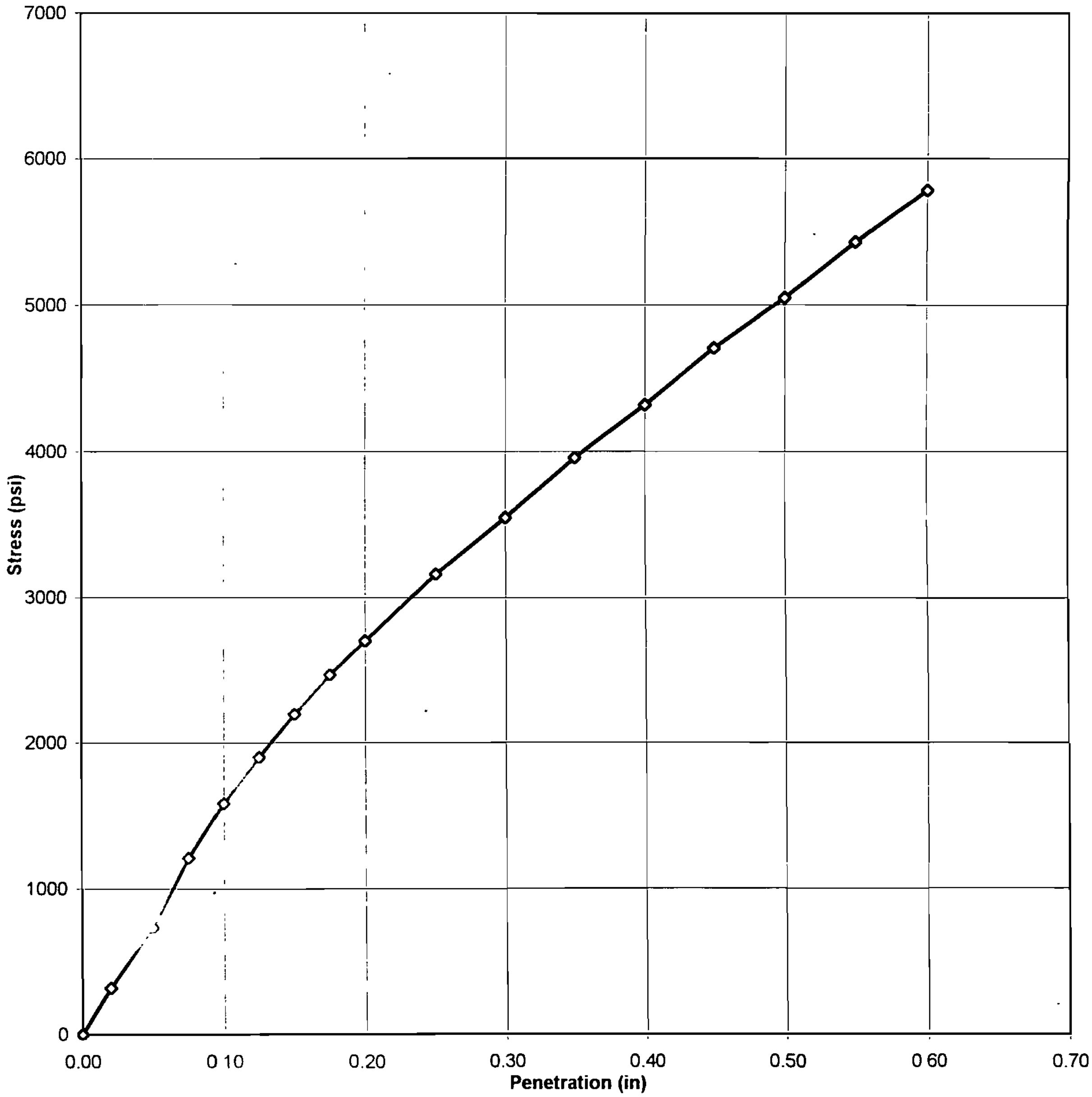
SINGLE POINT CBR TEST
ASTM D 1883-94(SOP-S27)

Client	TETRA TECH NUS	Boring No.	GFP-08-MB-02
Client Reference	GULFPORT N0567	Depth(ft.)	NA
Project No.	00248-02	Sample No.	PC ~~CK~~15
Lab ID	00248-02.006	Visual Description	BROWN CLAY, & ROCK FRAGMENTS, & PORTLAND CEMENT ~~KILN DUST~~

Penetration Stress vs. Penetration

CBR VALUE (0.1") **158.17 %**
CBR VALUE (0.2") **180.00 %**



Tested By JP/GU *Date* 10/2/00 *Checked By* [signature] *Date* 10.9.00

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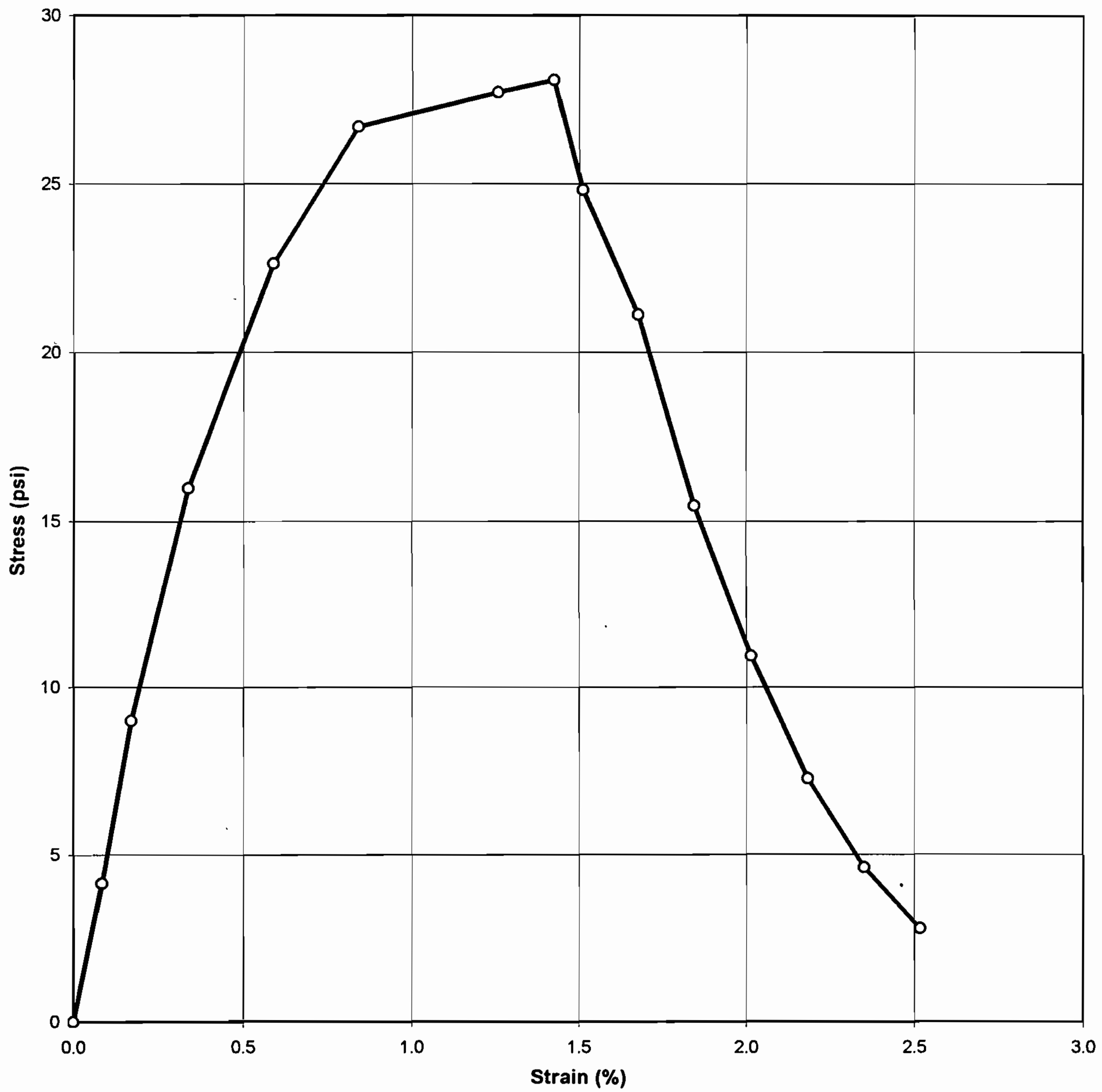
G

APPENDIX G

THIRD-TIER TESTING LABORATORY DATA SHEETS

UNCONFINED COMPRESSIVE STRENGTH
ASTM D2166-91 (SOP S-30)

Client	TETRA TECH NUS	Boring No.	GFB-08-MB-0~~3~~ 2 JJB 11/14/00
Client Reference	GULFPORT N0567	Depth (ft.)	CURED 3 DAYS
Project No.	00248-03	Sample No.	PC ~~CK~~05
Lab ID	00248-03.001	Visual Description:	BROWN STABILIZED SLUDGE



Tested By GU Date 11/9/00 Checked By JCM Date 11.14.00

DCN: CT-S30 DATE: 6-12-00 REVISION: 1

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UNCONFINED COMPRESSIVE STRENGTH
ASTM D2166-91 (SOP S-30)

Client	TETRA TECH NUS	Boring No.	GFB-08-MB-0~~3~~ 2 JJB 11/14/00
Client Reference	GULFPORT N0567	Depth (ft.)	CURED 3 DAYS
Project No.	00248-03	Sample No.	PC~~GK~~05
Lab ID	00248-03.001	Visual Description:	BROWN STABILIZED SLUDGE

INITIAL SAMPLE DIMENSIONS

Length 1(in)	5.956	Top Dia. (in)	3.007
Length 2(in)	5.961	Mid. Dia. (in)	2.977
Length 3(in)	5.957	Bot. Dia. (in)	2.965
Avg.Length(in	5.958	Area (in.^2)	6.989

WATER CONTENT

Tare No.	595
Wt. Tare + WS.(gms)	819.60
Wt. Tare + DS.(gms)	703.30
Wt. of Tare(gms)	86.87
% Moisture	18.87

UNIT WEIGHT

Wt. Tube & WS.(gms.)	1258.5	Sample Volume(cc.)	682.3
Wt. Of Tube(gms.)	0.00	Unit Wet Wt.(gms/cc)	1.84
Wt. Of WS.(gms.)	1258.5	Unit Wet Wt.(pcf.)	115.09
Diameter (in.)	2.98	Moisture Content, %	18.87
Length (in.)	5.96	Unit Dry Wt.(pcf.)	96.82
Length (cm.)	15.13		

DEFORMATION (in)	*LOAD (lbs)*	*STRAIN (%)*	*STRESS (psi)*
0.000	0	0.00	0.00
0.005	29	0.08	4.15
0.010	63	0.17	9.00
0.020	112	0.34	15.97
0.035	159	0.59	22.62
0.050	188	0.84	26.67
0.075	196	1.26	27.69
0.085	199	1.43	28.07
0.090	176	1.51	24.80
0.100	150	1.68	21.10
0.110	110	1.85	15.45
0.120	78	2.01	10.94
0.130	52	2.18	7.28
0.140	33	2.35	4.61
0.150	20	2.52	2.79

Tested By GU Date 11/9/00 Checked By JCM Date 11-14-00

DCN: CT-S30 DATE: 6-12-00 REVISION: 1
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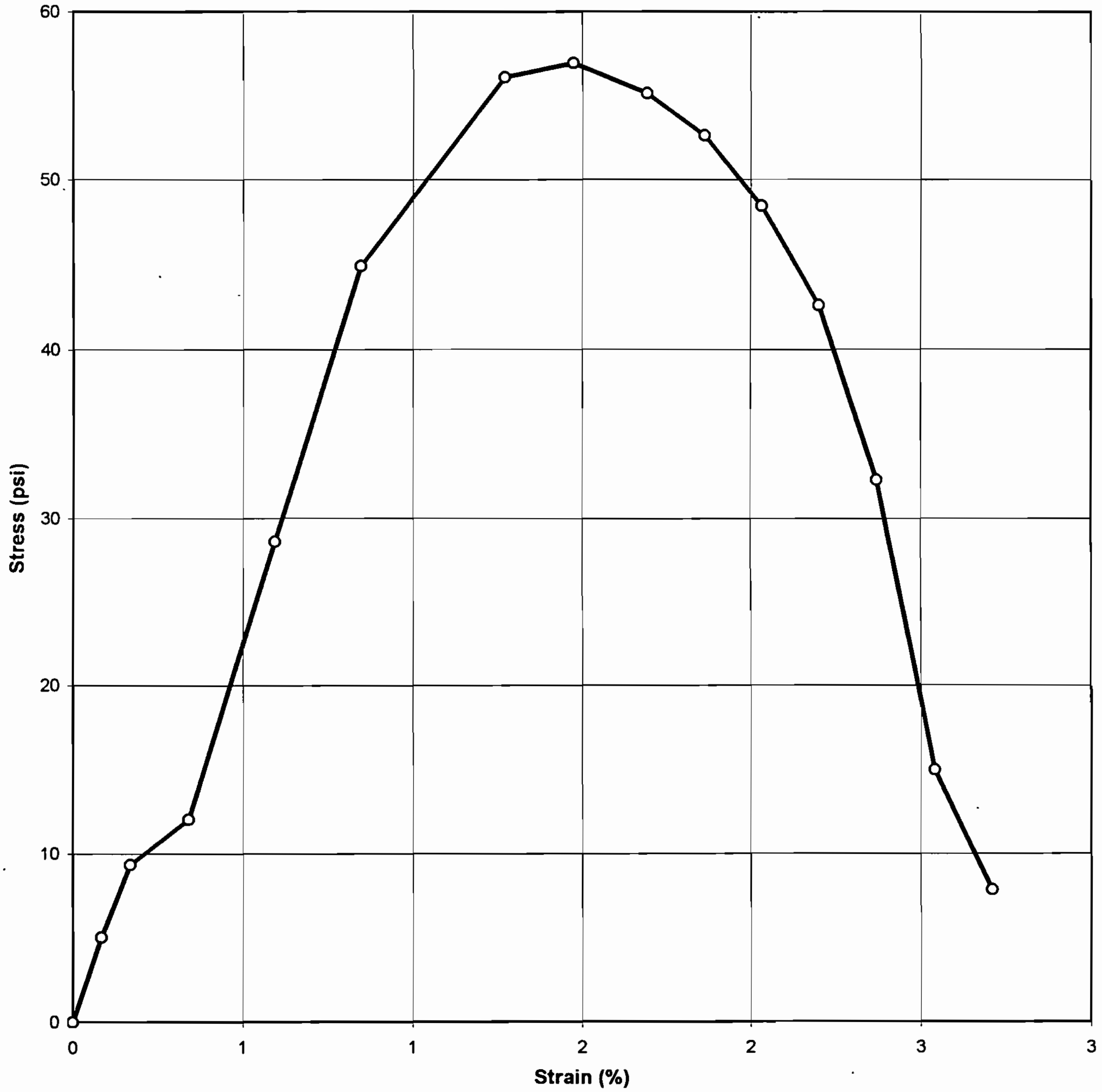
UNCONFINED COMPRESSIVE STRENGTH
ASTM D2166-91 (SOP S-30)

Client	TETRA TECH NUS	Boring No.	GFB-08-MB-0~~3~~ 2 JSB 11/5/00
Client Reference	GULFPORT NO567	Depth (ft.)	CURED 7 DAYS
Project No.	00248-03	Sample No.	PC ~~CK~~05
Lab ID	00248-03.001	Visual Description:	BROWN STABILIZED SLUDGE



Tested By GU/JP Date 10/27/00 Checked By DB Date 10/30/00

DCN: CT-S30 DATE: 6-12-00 REVISION: 1
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UNCONFINED COMPRESSIVE STRENGTH
ASTM D2166-91 (SOP S-30)

Client	TETRA TECH NUS	Boring No.	GFB-08-MB-~~03~~ 2 JJB 11/5/00
Client Reference	GULFPORT NO567	Depth (ft.)	CURED 7 DAYS
Project No.	00248-03	Sample No.	PC ~~CK~~05
Lab ID	00248-03.001	Visual Description:	BROWN STABILIZED SLUDGE

INITIAL SAMPLE DIMENSIONS

Length 1(in)	5.923	Top Dia. (in)	2.985
Length 2(in)	5.903	Mid. Dia. (in)	2.980
Length 3(in)	5.882	Bot. Dia. (in)	2.964
Avg.Length(in	5.903	Area (in.^2)	6.957

WATER CONTENT

Tare No.	608
Wt. Tare + WS.(gms)	1433.40
Wt. Tare + DS.(gms)	1223.90
Wt. of Tare(gms)	82.16
% Moisture	18.35

UNIT WEIGHT

Wt. Tube & WS.(gms.)	1354.2	Sample Volume(cc.)	673.0
Wt. Of Tube(gms.)	0.00	Unit Wet Wt.(gms/cc)	2.01
Wt. Of WS.(gms.)	1354.2	Unit Wet Wt.(pcf.)	125.56
Diameter (in.)	2.98	Moisture Content, %	18.35
Length (in.)	5.90	Unit Dry Wt.(pcf.)	106.10
Length (cm.)	14.99		

DEFORMATION (in)	*LOAD (lbs)*	*STRAIN (%)*	*STRESS (psi)*
0.000	0	0.00	0.00
0.005	35	0.08	5.03
0.010	65	0.17	9.33
0.020	84	0.34	12.03
0.035	200	0.59	28.58
0.050	315	0.85	44.89
0.075	395	1.27	56.05
0.087	402	1.47	56.93
0.100	390	1.69	55.10
0.110	373	1.86	52.61
0.120	344	2.03	48.44
0.130	303	2.20	42.59
0.140	230	2.37	32.27
0.150	107	2.54	14.99
0.160	56	2.71	7.83

Tested By GU/JP Date 10/27/00 Checked By DB Date 10/30/00

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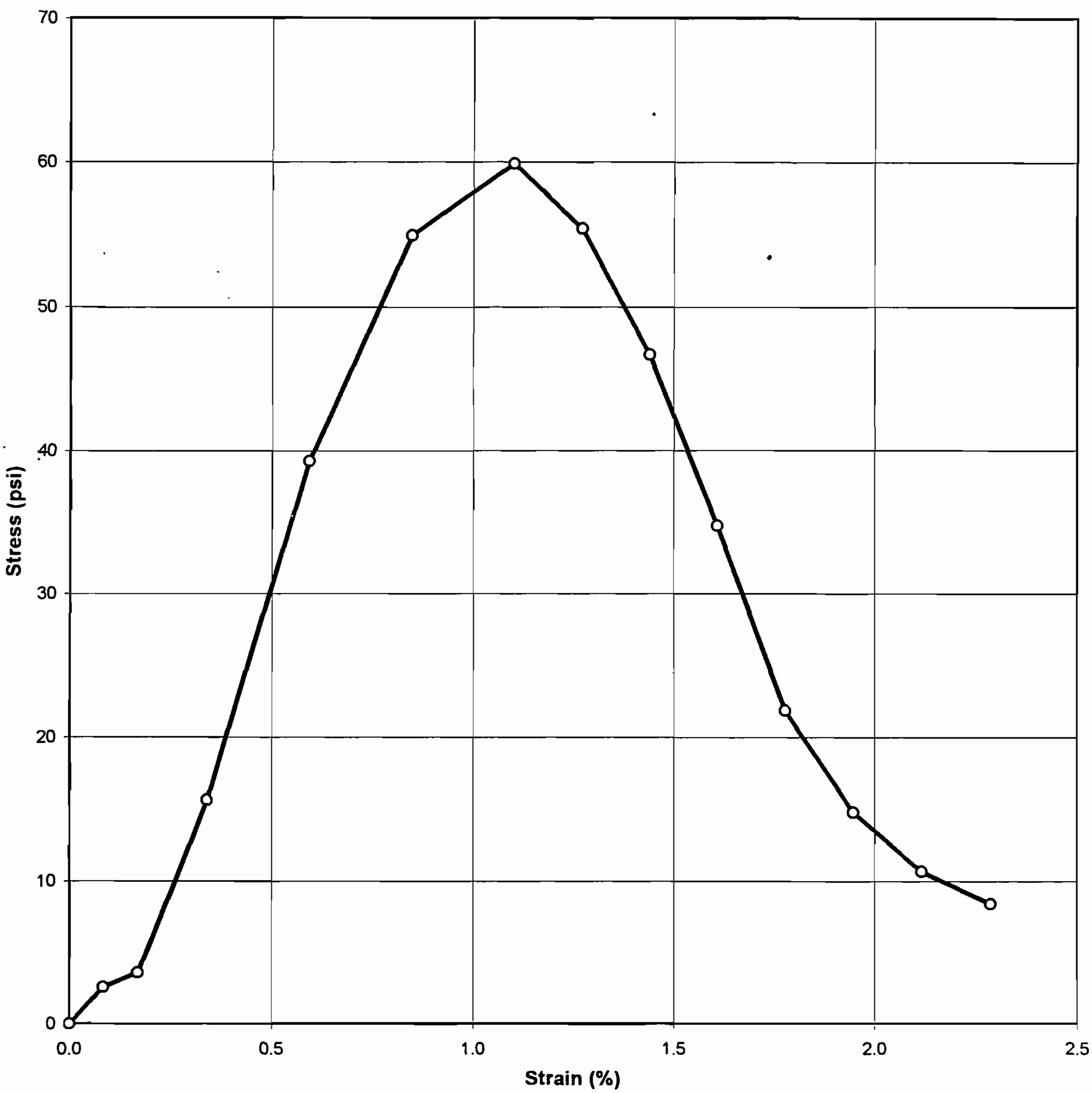
UNCONFINED COMPRESSIVE STRENGTH

ASTM D2166-91 (SOP S-30)

Client	TETRA TECH NUS	Boring No.	GFB-08-MB-~~03~~ 2 JJB 11/14/00
Client Reference	GULFPORT N0567	Depth (ft.)	CURED 3 DAYS
Project No.	00248-03	Sample No.	PC ~~CK~~10
Lab ID	00248-03.002	Visual Description:	BROWN STABILIZED SLUDGE



Tested By GU Date 11/9/00 Checked By Jem Date 11-14-00

DCN: CT-S30 DATE: 6-12-00 REVISION: 1

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UNCONFINED COMPRESSIVE STRENGTH
ASTM D2166-91 (SOP S-30)

Client	TETRA TECH NUS	Boring No.	GFB-08-MB-032 228 11/14/00
Client Reference	GULFPORT N0567	Depth (ft.)	CURED 3 DAYS
Project No.	00248-03	Sample No.	PC ~~CK~~10
Lab ID	00248-03.002	Visual Description:	BROWN STABILIZED SLUDGE

INITIAL SAMPLE DIMENSIONS

Length 1(in)	5.900	Top Dia. (in)	2.992
Length 2(in)	5.904	Mid. Dia. (in)	2.976
Length 3(in)	5.902	Bot. Dia. (in)	2.968
Avg.Length(in	5.902	Area (in.^2)	6.968

WATER CONTENT

Tare No.	1694
Wt. Tare + WS.(gms)	721.40
Wt. Tare + DS.(gms)	626.30
Wt. of Tare(gms)	84.02
% Moisture	17.54

UNIT WEIGHT

Wt. Tube & WS.(gms.)	1217.6	Sample Volume(cc.)	674.0
Wt. Of Tube(gms.)	0.00	Unit Wet Wt.(gms/cc)	1.81
Wt. Of WS.(gms.)	1217.6	Unit Wet Wt.(pcf.)	112.73
Diameter (in.)	2.98	Moisture Content, %	17.54
Length (in.)	5.90	Unit Dry Wt.(pcf.)	95.91
Length (cm.)	14.99		

DEFORMATION (in)	*LOAD (lbs)*	*STRAIN (%)*	*STRESS (psi)*
0.000	0	0.00	0.00
0.005	18	0.08	2.58
0.010	25	0.17	3.58
0.020	109	0.34	15.59
0.035	275	0.59	39.23
0.050	386	0.85	54.92
0.065	422	1.10	59.89
0.075	391	1.27	55.40
0.085	330	1.44	46.67
0.095	246	1.61	34.73
0.105	155	1.78	21.85
0.115	105	1.95	14.77
0.125	76	2.12	10.68
0.135	60	2.29	8.41

Tested By GU Date 11/9/00 Checked By JCM Date 11-14-00

DCN: CT-S30 DATE: 6-12-00 REVISION: 1
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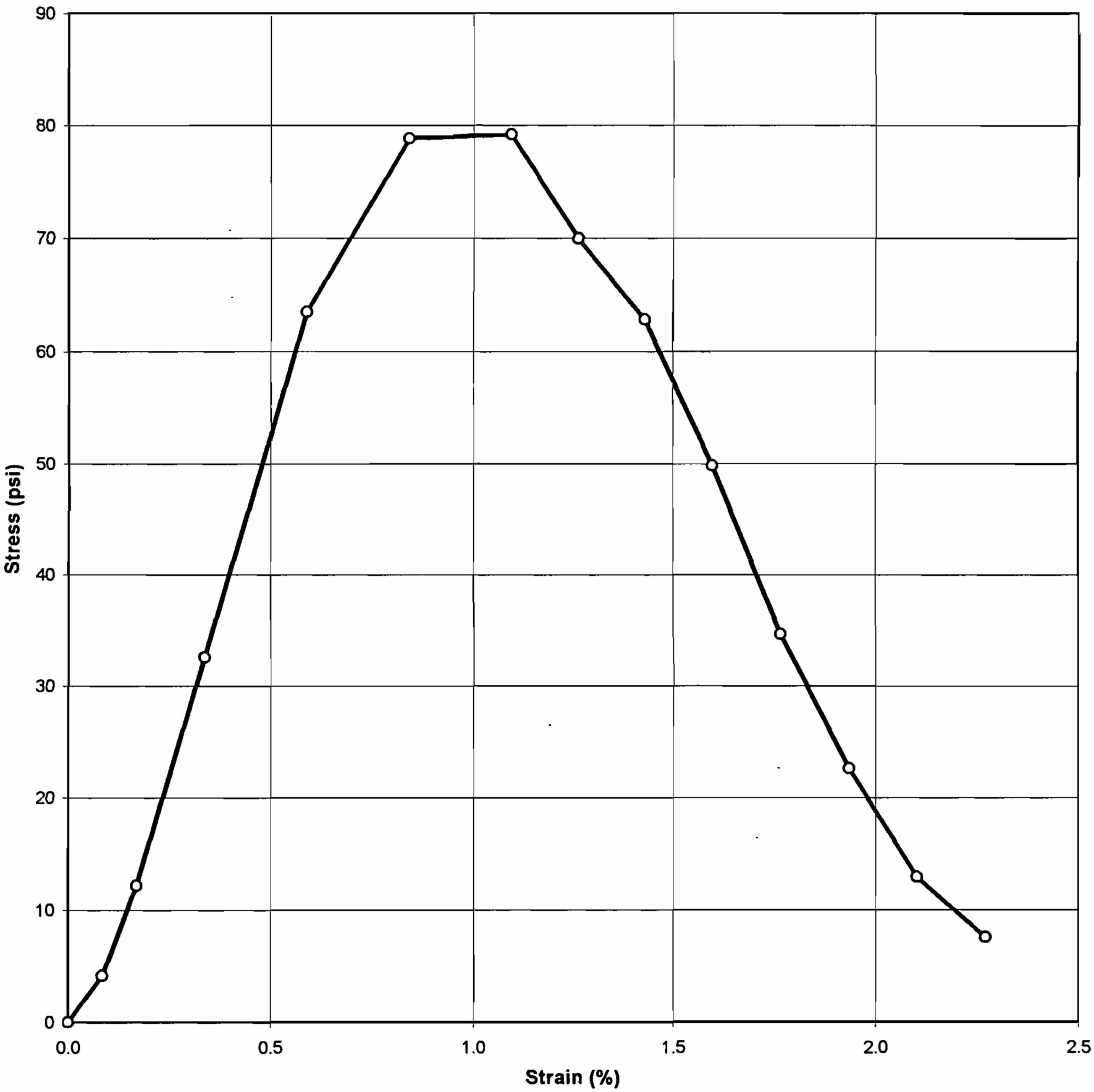
UNCONFINED COMPRESSIVE STRENGTH
ASTM D2166-91 (SOP S-30)

Client	TETRA TECH NUS	Boring No.	GFB-08-MB-~~03~~ 2 JJB 11/5/00
Client Reference	GULFPORT NO567	Depth (ft.)	CURED 7 DAYS
Project No.	00248-03	Sample No.	PC ~~CK~~10
Lab ID	00248-03.002	Visual Description:	BROWN STABILIZED SLUDGE



Tested By GU/JP Date 10/27/00 Checked By DB Date 10/30/00

DCN: CT-S30 DATE: 6-12-00 REVISION: 1
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UNCONFINED COMPRESSIVE STRENGTH
ASTM D2166-91 (SOP S-30)

Client	TETRA TECH NUS	Boring No.	GFB-08-MB-~~03~~ 02 JJB 11/5/00
Client Reference	GULFPORT NO567	Depth (ft.)	CURED 7 DAYS
Project No.	00248-03	Sample No.	PC ~~CK~~10
Lab ID	00248-03.002	Visual Description:	BROWN STABILIZED SLUDGE

INITIAL SAMPLE DIMENSIONS

Length 1(in)	5.937	Top Dia. (in)	2.984
Length 2(in)	5.939	Mid. Dia. (in)	2.988
Length 3(in)	5.952	Bot. Dia. (in)	2.966
Avg.Length(in	5.943	Area (in.^2)	6.972

WATER CONTENT

Tare No.	609
Wt. Tare + WS.(gms)	1369.70
Wt. Tare + DS.(gms)	1187.20
Wt. of Tare(gms)	82.23
% Moisture	16.52

UNIT WEIGHT

Wt. Tube & WS.(gms.)	1290.2	Sample Volume(cc.)	678.9
Wt. Of Tube(gms.)	0.00	Unit Wet Wt.(gms/cc)	1.90
Wt. Of WS.(gms.)	1290.2	Unit Wet Wt.(pcf.)	118.59
Diameter (in.)	2.98	Moisture Content, %	16.52
Length (in.)	5.94	Unit Dry Wt.(pcf.)	101.78
Length (cm.)	15.09		

DEFORMATION (in)	*LOAD (lbs)*	*STRAIN (%)*	*STRESS (psi)*
0.000	0	0.00	0.00
0.005	29	0.08	4.16
0.010	85	0.17	12.17
0.020	228	0.34	32.59
0.035	445	0.59	63.46
0.050	554	0.84	78.80
0.065	558	1.09	79.16
0.075	494	1.26	69.97
0.085	444	1.43	62.78
0.095	353	1.60	49.83
0.105	246	1.77	34.66
0.115	161	1.94	22.65
0.125	92	2.10	12.92
0.135	54	2.27	7.57

Tested By GU/JP Date 10/27/00 Checked By DB Date 10/30/00

 DCN: CT-S30 DATE: 6-12-00 REVISION: 1 *C:\MSOFFICE\EXCEL\PrintQ\[D63 xls]Sheet1*

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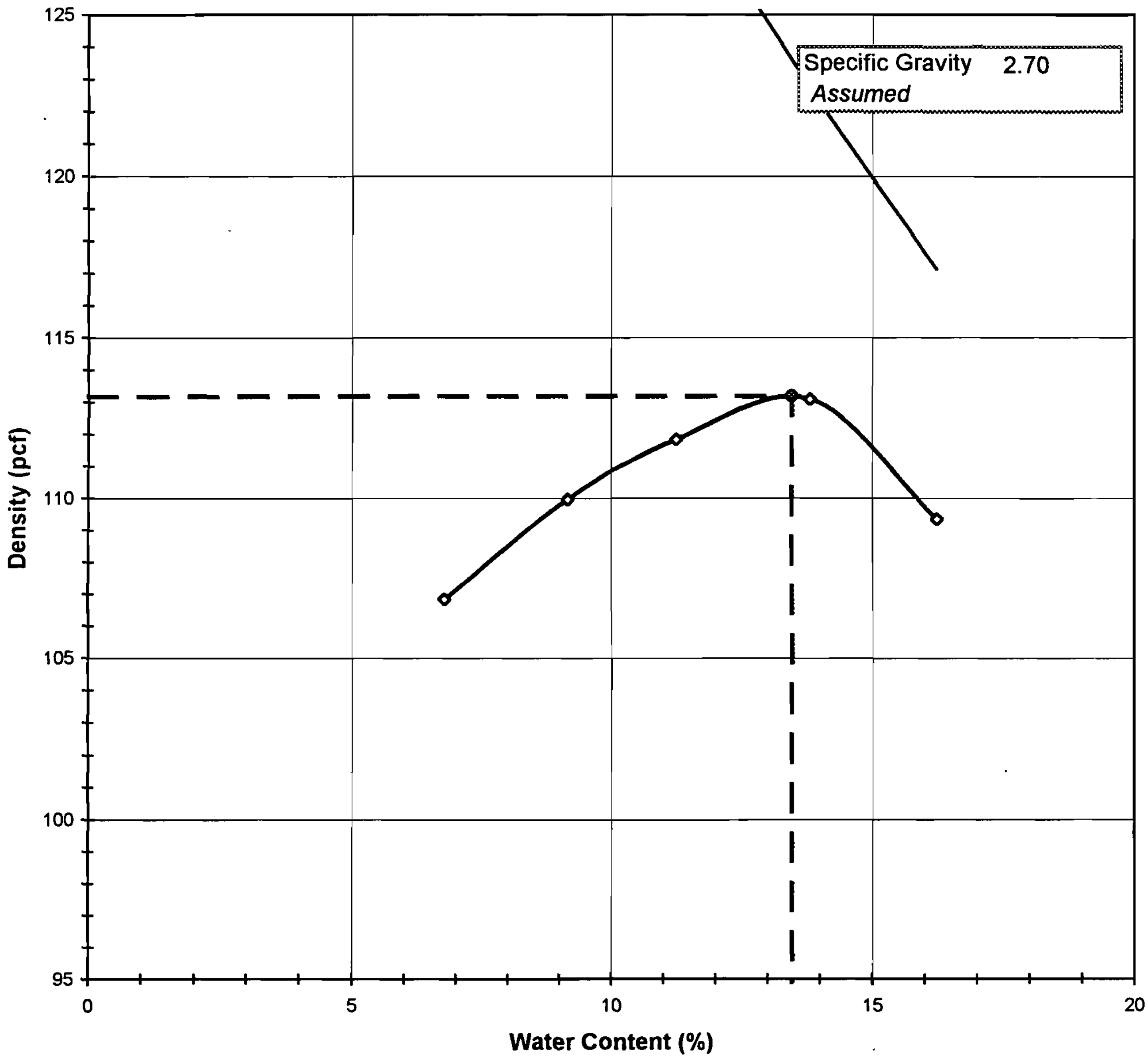
MOISTURE DENSITY RELATIONSHIP

ASTM D698-91 SOP-S12

Client	TETRA TECH NUS	Boring No.	GFB-08-MB-03
Client Reference	GULFPORT NO567	Depth (ft)	NA
Project No.	00248-03	Sample No.	PC ~~CK~~05-SD15
Lab ID	00248-03.003	Test Method	**STANDARD**

Visual Description BROWN CLAY, ROCK FRAGMENTS, AND PORTLAND CEMENT ~~KILN DUST~~

Optimum Water Content	**13.5**
Maximum Dry Density	**113.2**



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 DCN:CT-S12 DATE: 6-25-98 REVISION 3 *C:\MSOFFICE\EXCEL\PrintQ\[D41.xls]Sheet1*

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MOISTURE - DENSITY RELATIONSHIP

ASTM D698-91 SOP-S12

Client	TETRA TECH NUS	Boring No.	GFB-08-MB-03
Client Reference	GULFPORT NO567	Depth (ft)	NA
Project No.	00248-03	Sample No.	PC ~~CK~~05-SD15
Lab ID	00248-03.003		

Visual Description BROWN CLAY, ROCK FRAGMENTS, AND PORTLAND CEMENT K~~ILN DUST~~

Total Weight of the Sample (gm)	NA
As Received Water Content(%)	NA
Assumed Specific Gravity	2.70
Percent Retained on 3/4"	NA
Percent Retained on 3/8"	NA
Percent Retained on #4	NA
Oversize Material	Not included
Procedure Used	B

TestType	STANDARD
Rammer Weight (lbs)	5.5
Rammer Drop (in)	12
Rammer Type	MECHANICAL
Machine ID	G774
Mold ID	G777
Mold diameter	4"
Weight of the Mold	4205
Volume of the Mold(cc)	944

Mold / Specimen

Point No.	**1**	**2**	**3**	**4**	**5**
Wt. of Mold & WS (gm)	5931	6021	6087	6152	6128
Wt.of Mold (gm)	4205	4205	4205	4205	4205
Wt. of WS	1726	1816	1882	1947	1923
Mold Volume (cc)	944	944	944	944	944

Moisture Content / Density

Tare Number	615	1710	584	595	614
Wt. of Tare & WS (gm)	438.60	417.90	400.10	463.40	388.64
Wt. of Tare & DS (gm)	416.10	389.75	367.96	417.70	346.20
Wt. of Tare (gm)	84.52	82.69	82.28	86.93	84.89
Wt. of Water (gm)	22.50	28.15	32.14	45.70	42.44
Wt. of DS (gm)	331.58	307.06	285.68	330.77	261.31

Wet Density (gm/cc)	1.83	1.92	1.99	2.06	2.04
Wet Density (pcf)	114.1	120.0	124.4	128.7	127.1
Moisture Content (%)	**6.8**	**9.2**	**11.3**	**13.8**	**16.2**
Dry Density (pcf)	**106.8**	**110.0**	**111.8**	**113.1**	**109.4**
Pocket Penetrometer (tsf) TOP	0.0	0.0	0.0	3.5	1.0

Zero Air Voids

Moisture Content (%)	11.3	13.8	16.2
Dry Unit Weight (pcf)	129.2	122.7	117.1

Tested By JP *Date* 10/25/00 *Checked By* JH/C *Date* 10/27/00

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SINGLE POINT CBR TEST

ASTM D 1883-94(SOP-S27)

Client	TETRA TECH NUS	Boring No.	GFB-08-MB-03
Client Reference	GULFPORT NO567	Depth(ft.)	NA
Project No.	00248-03	Sample No.	PC ~~CK~~05-SD15
Lab ID	00248-03.003	Visual Description	BROWN CLAY,ROCK FRAGMENTS,& PORTLAND CEMENT ~~KILN DUST~~

		Density Measurement	Before Soaking	After Soaking	
Test Type	**STANDARD**	Wt. Mold & WS (gm.)	11507	11502	
Molding Method	C	Wt. WS (gm.)	4234	4229	
Mold ID	A	Sample Volume (cc)	2124	2122	
Wt. of Mold (gm.)	7273	Wet Density (gm./cc)	1.99	1.99	
Mold Volume (cc)	2124	Wet Density (pcf)	124.4	124.3	
					Top 1"
Surcharge (lbs.)	**20**	Tare No.	609	1913	1614
Piston Area (in^2)	3	Wt. of T+WS (gm.)	747.4	941.8	543.6
Sample Height	4.58	Wt. of T+DS (gm.)	637.4	809.3	474.8
		Wt of Tare (gm.)	82.24	103.67	99.64
Sample Conditions	Soaked	Moisture Content	19.8%	18.8%	18.3%
Blows per Layer	**56**				
		Dry Density (pcf)	**103.8**	**104.7**	
		Dry Density (gm./cc)	**1.66**	**1.68**	

Placed @ as received water content

Piston isplacement (in.)	Load (lbs.)	Penetration Stress (psi.)
0	0	0.0
0.025	1085	361.7
0.050	1480	493.3
0.075	1645	548.3
0.100	1780	593.3
0.125	1960	653.3
0.150	2130	710.0
0.175	2275	758.3
0.200	2400	800.0
0.250	2655	885.0
0.300	2900	966.7
0.350	3195	1065.0
0.400	3460	1153.3
0.450	3725	1241.7
0.500	4000	1333.3
0.550	4270	1423.3
0.600	4555	1518.3

Swell Measurement

Elapsed Time (hrs)	Dial Gauge (Div)	Percent Swell
0	500	0.00%
0.1	497	-0.07%
0.3	497	-0.07%
0.4	496	-0.09%
1.4	496	-0.09%
19.7	496	-0.09%
96.2	496	-0.09%

1Division 0.001 in.

Tested By *JP/GU* *Date* *10/19/00* *Checked By* JMO *Date* 10/27/00

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DCN: CT-S27
DATE: 12/16/96
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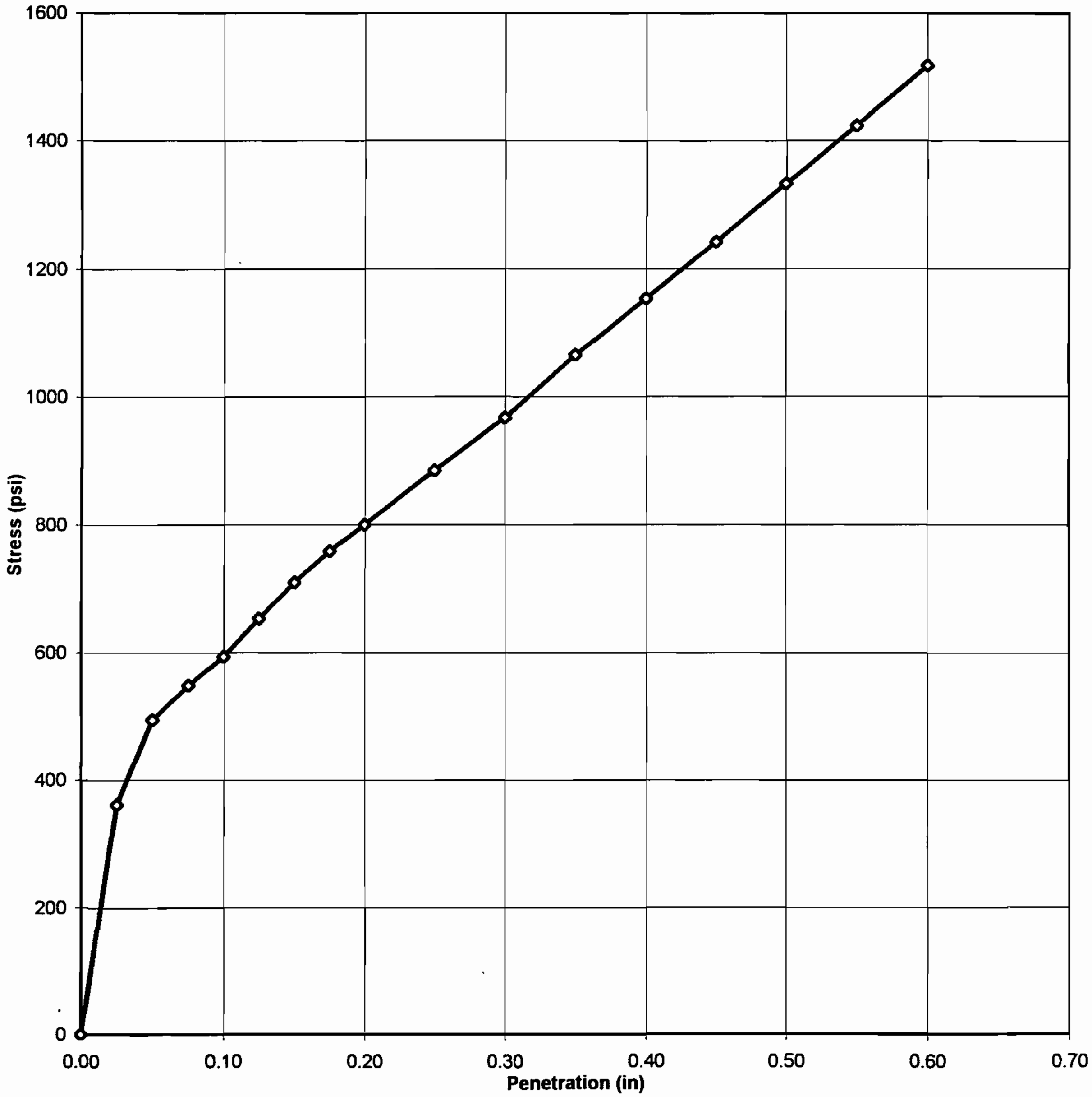
SINGLE POINT CBR TEST
ASTM D 1883-94(SOP-S27)

Client	TETRA TECH NUS	Boring No.	GFB-08-MB-03
Client Reference	GULFPORT NO567	Depth(ft.)	NA
Project No.	00248-03	Sample No.	PC ~~CK~~05-SD15
Lab ID	00248-03.003	Visual Description	BROWN CLAY,ROCK FRAGMENTS,& PORTLAND CEMENT ~~KILN DUS~~T

Penetration Stress vs. Penetration

CBR VALUE (0.1") **59.33 %**
CBR VALUE (0.2") **53.33 %**



Tested By *JP/GU* *Date* *10/19/00* *Checked By* JHO *Date* 10/27/00

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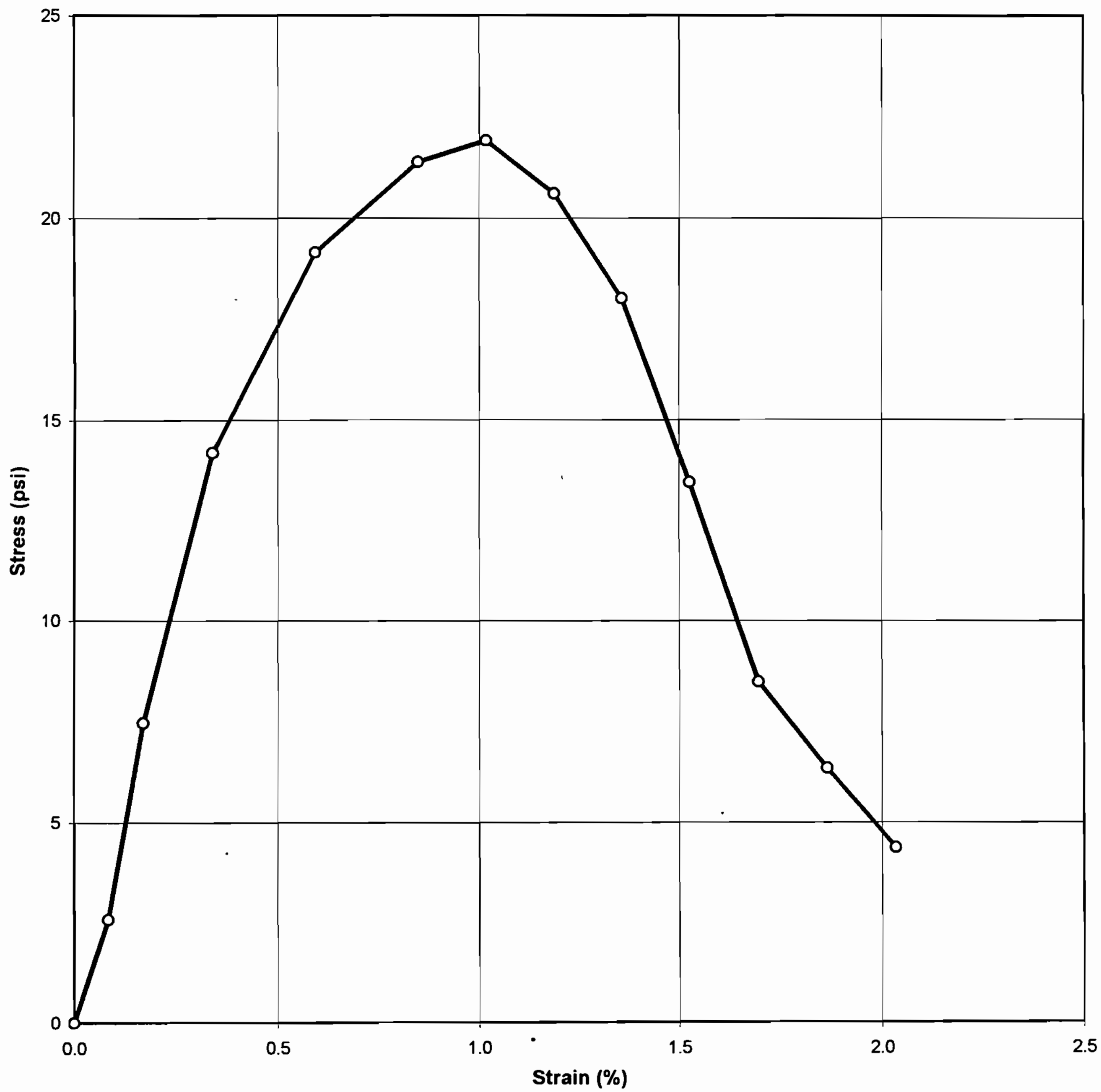
UNCONFINED COMPRESSIVE STRENGTH
ASTM D2166-91 (SOP S-30)

Client	TETRA TECH NUS	Boring No.	GFB-08-MB-03
Client Reference	GULFPORT N0567	Depth (ft.)	CURED 3 DAYS
Project No.	00248-03	Sample No.	PC ~~CK~~05-SD15
Lab ID	00248-03.003	Visual Description:	BROWN STABILIZED SLUDGE



Tested By GU Date 11/9/00 Checked By Jem Date 11.14 00

 DCN: CT-S30 DATE: 6-12-00 REVISION: 1 C \MSOFFICE\EXCEL\PrintQ\[E33 xls]Sheet1

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UNCONFINED COMPRESSIVE STRENGTH
ASTM D2166-91 (SOP S-30)

Client	TETRA TECH NUS	Boring No.	GFB-08-MB-03
Client Reference	GULFPORT N0567	Depth (ft.)	CURED 3 DAYS
Project No.	00248-03	Sample No.	PC ~~GK~~05-SD15
Lab ID	00248-03.003	Visual Description:	BROWN STABILIZED SLUDGE

INITIAL SAMPLE DIMENSIONS

Length 1(in)	5.886	Top Dia. (in)	2.962
Length 2(in)	5.907	Mid. Dia. (in)	3.001
Length 3(in)	5.899	Bot. Dia. (in)	2.964
Avg.Length(in	5.897	Area (in.^2)	6.954

WATER CONTENT

Tare No.	551
Wt. Tare + WS.(gms)	701.20
Wt. Tare + DS.(gms)	599.10
Wt. of Tare(gms)	84.50
% Moisture	19.84

UNIT WEIGHT

Wt. Tube & WS.(gms.)	1250.2	Sample Volume(cc.)	672.1
Wt. Of Tube(gms.)	0.00	Unit Wet Wt.(gms/cc)	1.86
Wt. Of WS.(gms.)	1250.2	Unit Wet Wt.(pcf.)	116.08
Diameter (in.)	2.98	Moisture Content, %	19.84
Length (in.)	5.90	Unit Dry Wt.(pcf.)	96.86
Length (cm.)	14.98		

DEFORMATION (in)	*LOAD (lbs)*	*STRAIN (%)*	*STRESS (psi)*
0.000	0	0.00	0.00
0.005	18	0.08	2.59
0.010	52	0.17	7.46
0.020	99	0.34	14.19
0.035	134	0.59	19.15
0.050	150	0.85	21.39
0.060	154	1.02	21.92
0.070	145	1.19	20.60
0.080	127	1.36	18.01
0.090	95	1.53	13.45
0.100	60	1.70	8.48
0.110	45	1.87	6.35
0.120	31	2.03	4.37

Tested By GU Date 11/9/00 Checked By Jcm Date 11-14-00

DCN: CT-S30 DATE: 6-12-00 REVISION: 1
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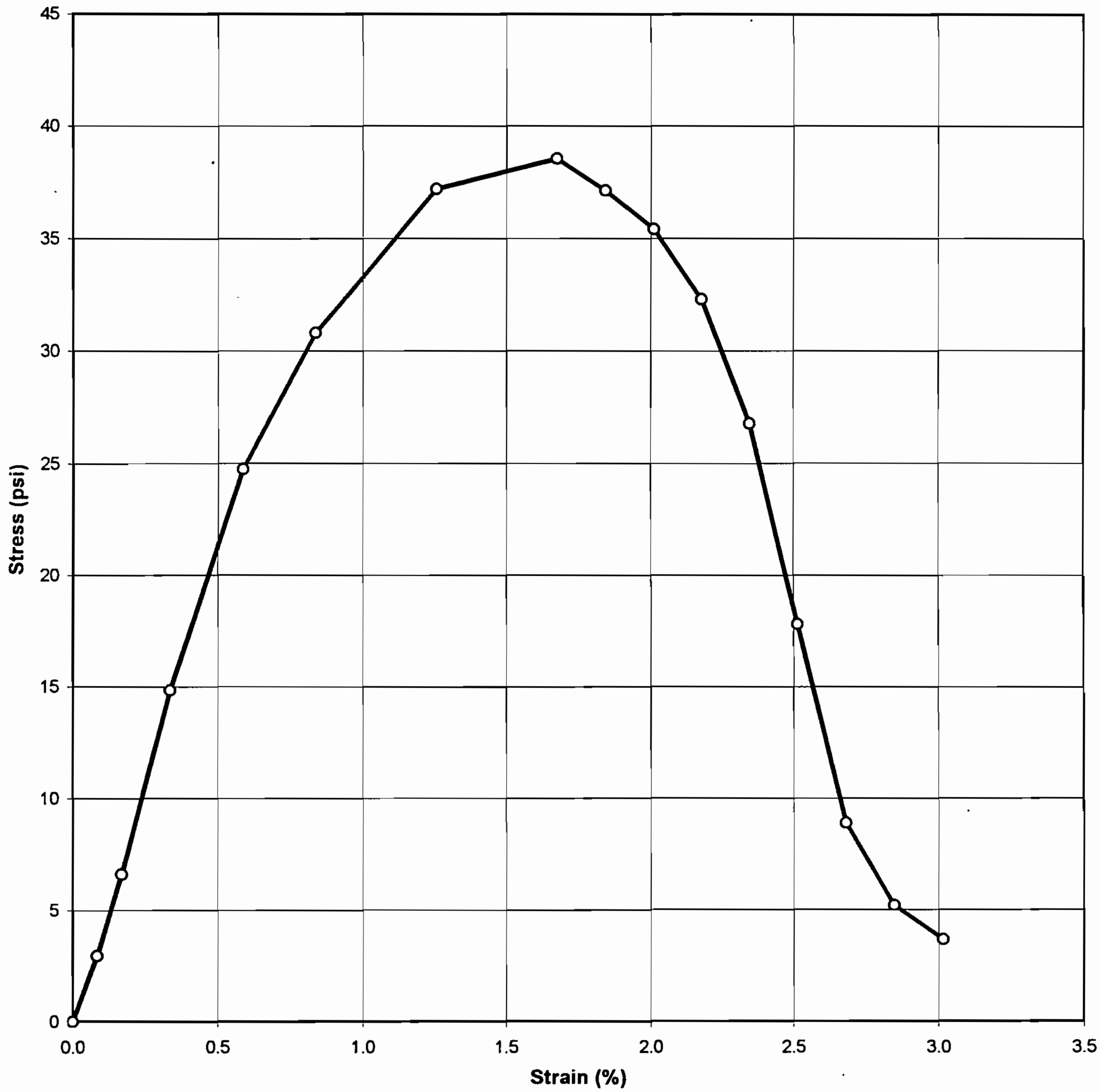
UNCONFINED COMPRESSIVE STRENGTH
ASTM D2166-91 (SOP S-30)

Client	TETRA TECH NUS	Boring No.	GFB-08-MB-03
Client Reference	GULFPORT NO567	Depth (ft.)	CURED 7 DAYS
Project No.	00248-03	Sample No.	PC~~CK~~05-SD15
Lab ID	00248-03.003	Visual Description:	BROWN STABILIZED SLUDGE



Tested By GU/JP Date 10/27/00 Checked By DB Date 10/30/00

 DCN: CT-S30 DATE: 6-12-00 REVISION: 1 C:\MSOFFICE\EXCEL\PrintQ\[D64 xls]Sheet1

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UNCONFINED COMPRESSIVE STRENGTH
ASTM D2166-91 (SOP S-30)

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Client	TETRA TECH NUS	Boring No.	GFB-08-MB-03
Client Reference	GULFPORT NO567	Depth (ft.)	CURED 7 DAYS
Project No.	00248-03	Sample No.	PC~~CK~~05-SD15
Lab ID	00248-03.003	Visual Description:	BROWN STABILIZED SLUDGE

INITIAL SAMPLE DIMENSIONS

Length 1(in)	5.976	Top Dia. (in)	3.032
Length 2(in)	5.970	Mid. Dia. (in)	3.013
Length 3(in)	5.954	Bot. Dia. (in)	2.985
Avg.Length(in	5.967	Area (in.^2)	7.116

WATER CONTENT

Tare No.	561
Wt. Tare + WS.(gms)	1419.90
Wt. Tare + DS.(gms)	1184.50
Wt. of Tare(gms)	86.52
% Moisture	21.44

UNIT WEIGHT

Wt. Tube & WS.(gms.)	1336.5	Sample Volume(cc.)	695.8
Wt. Of Tube(gms.)	0.00	Unit Wet Wt.(gms/cc)	1.92
Wt. Of WS.(gms.)	1336.5	Unit Wet Wt.(pcf.)	119.87
Diameter (in.)	3.01	Moisture Content, %	21.44
Length (in.)	5.97	Unit Dry Wt.(pcf.)	98.70
Length (cm.)	15.16		

DEFORMATION (in)	*LOAD (lbs)*	*STRAIN (%)*	*STRESS (psi)*
0.000	0	0.00	0.00
0.005	21	0.08	2.95
0.010	47	0.17	6.59
0.020	106	0.34	14.85
0.035	177	0.59	24.73
0.050	221	0.84	30.80
0.075	268	1.26	37.19
0.100	279	1.68	38.55
0.110	269	1.84	37.11
0.120	257	2.01	35.39
0.130	235	2.18	32.31
0.140	195	2.35	26.76
0.150	130	2.51	17.81
0.160	65	2.68	8.89
0.170	38	2.85	5.19
0.180	27	3.02	3.68

Tested By GU/JP Date 10/27/00 Checked By DB Date 10/30/00

DCN: CT-S30 DATE: 6-12-00 REVISION: 1 *C:\MSOFFICE\EXCEL\PrintQ\[D64 xls]Sheet1*

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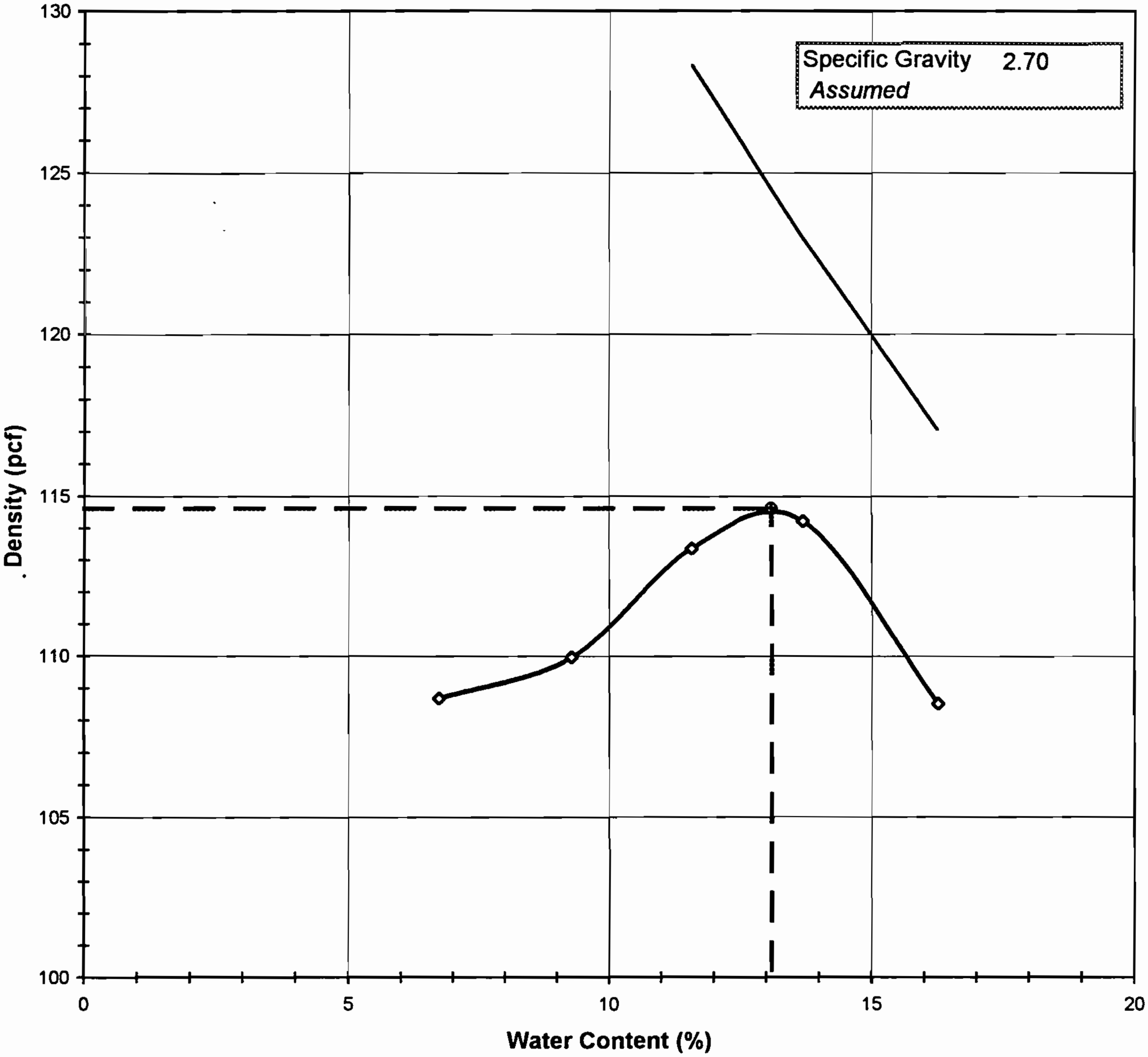
MOISTURE DENSITY RELATIONSHIP

ASTM D698-91 SOP-S12

Client	TETRA TECH NUS	Boring No.	GFB-08-MB-03
Client Reference	GULFPORT NO567	Depth (ft)	NA
Project No.	00248-03	Sample No.	PC ~~CK~~05-SD30
Lab ID	00248-03.004	Test Method	**STANDARD**

Visual Description BROWN CLAY, ROCK FRAGMENTS, AND CEMENT K~~ILN DUST~~ PORTLAND

Optimum Water Content	**13.1**
Maximum Dry Density	**114.6**



Tested By JP *Date* 10/25/00 *Checked By* JMO *Date* 10/27/00

 DCN:CT-S12 DATE: 6-25-98 REVISION 3 *C:\MSOFFICE\EXCEL\PrintQ\[D42.xls]Sheet1*

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MOISTURE - DENSITY RELATIONSHIP

ASTM D698-91 SOP-S12

Client	TETRA TECH NUS	Boring No.	GFB-08-MB-03
Client Reference	GULFPORT NO567	Depth (ft)	NA
Project No.	00248-03	Sample No.	PC ~~CK~~05-SD30
Lab ID	00248-03.004		

Visual Description BROWN CLAY, ROCK FRAGMENTS, AND PORTLAND CEMENT ~~KILN DUST~~

Total Weight of the Sample (gm)	NA
As Received Water Content(%)	NA
Assumed Specific Gravity	2.70
Percent Retained on 3/4"	NA
Percent Retained on 3/8"	NA
Percent Retained on #4	NA
Oversize Material	Not included
Procedure Used	B

TestType	STANDARD
Rammer Weight (lbs)	5.5
Rammer Drop (in)	12
Rammer Type	MECHANICAL
Machine ID	G774
Mold ID	G777
Mold diameter	4"
Weight of the Mold	4205
Volume of the Mold(cc)	944

Mold / Specimen

Point No.	1	2	3	4	5
Wt. of Mold & WS (gm)	5960	6023	6119	6170	6114
Wt.of Mold (gm)	4205	4205	4205	4205	4205
Wt. of WS	1755	1818	1914	1965	1909
Mold Volume (cc)	944	944	944	944	944

Moisture Content / Density

Tare Number	785	564	1720	579	558
Wt. of Tare & WS (gm)	400.90	387.79	348.33	426.80	590.90
Wt. of Tare & DS (gm)	381.03	361.87	320.67	385.49	519.60
Wt. of Tare (gm)	85.67	82.61	82.02	84.02	81.48
Wt. of Water (gm)	19.87	25.92	27.66	41.31	71.30
Wt. of DS (gm)	295.36	279.26	238.65	301.47	438.12

Wet Density (gm/cc)	1.86	1.93	2.03	2.08	2.02
Wet Density (pcf)	116.0	120.2	126.5	129.9	126.2
Moisture Content (%)	**6.7**	**9.3**	**11.6**	**13.7**	**16.3**
Dry Density (pcf)	**108.7**	**110.0**	**113.4**	**114.2**	**108.5**
Pocket Penetrometer (tsf) TOP	0.0	0.0	0.0	2.5	1.0

Zero Air Voids

Moisture Content (%)	11.6	13.7	16.3
Dry Unit Weight (pcf)	128.3	123.0	117.0

Tested By JP *Date* 10/25/00 *Checked By* JMO *Date* 10/27/00

DCN:CT-S12 DATE: 6-25-98 REVISION 3

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DCN: CT-S27
DATE: 12/16/96
REVISION: 1

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SINGLE POINT CBR TEST

ASTM D 1883-94(SOP-S27)

Client	TETRA TECH NUS	Boring No.	GFB-08-MB-03
Client Reference	GULFPORT NO567	Depth(ft.)	NA
Project No.	00248-03	Sample No.	PC ~~CK~~05-SD30
Lab ID	00248-03.004	Visual Description	BROWN CLAY,ROCK FRAGMENTS,& PORTLAND CEMENT ~~KILN DUST~~

		Density Measurement	Before Soaking	After Soaking	
Test Type	STANDARD	Wt. Mold & WS (gm.)	11426	11407	
Molding Method	C	Wt. WS (gm.)	4106	4087	
Mold ID	B	Sample Volume (cc)	2124	2117	
Wt. of Mold (gm.)	7320	Wet Density (gm./cc)	1.93	1.93	
Mold Volume (cc)	2124	Wet Density (pcf)	120.6	120.4	
					Top 1"
Surcharge (lbs.)	**20**	Tare No.	615	1084	1631
Piston Area (in^2)	3	Wt. of T+WS (gm.)	824.9	965.1	631.6
Sample Height	4.58	Wt. of T+DS (gm.)	690	822.5	538.4
		Wt of Tare (gm.)	84.55	100.13	94.36
Sample Conditions	Soaked	Moisture Content	22.3%	19.7%	21.0%
Blows per Layer	**56**				
		Dry Density (pcf)	**98.6**	**100.5**	
		Dry Density (gm./cc)	**1.58**	**1.61**	

Placed @ as received water content

Piston isplacement (in.)	Load (lbs.)	Penetration Stress (psi.)
0	0	0.0
0.025	870	290.0
0.050	1035	345.0
0.075	1150	383.3
0.100	1290	430.0
0.125	1405	468.3
0.150	1495	498.3
0.175	1565	521.7
0.200	1675	558.3
0.250	1875	625.0
0.300	2080	693.3
0.350	2275	758.3
0.400	2465	821.7
0.450	2655	885.0
0.500	2855	951.7
0.550	3055	1018.3
0.600	3260	1086.7

Swell Measurement

Elapsed Time (hrs)	Dial Gauge (Div)	Percent Swell
0	500	0.00%
0.1	490	-0.22%
0.3	488	-0.26%
0.4	486	-0.31%
1.4	485	-0.33%
19.7	485	-0.33%
96.2	485	-0.33%

1Division 0.001 in.

Tested By JP/GU *Date* 10/19/00 *Checked By* JMO *Date* 10/27/00

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DCN:	CT-S27
DATE:	12/16/96
REVISION:	1

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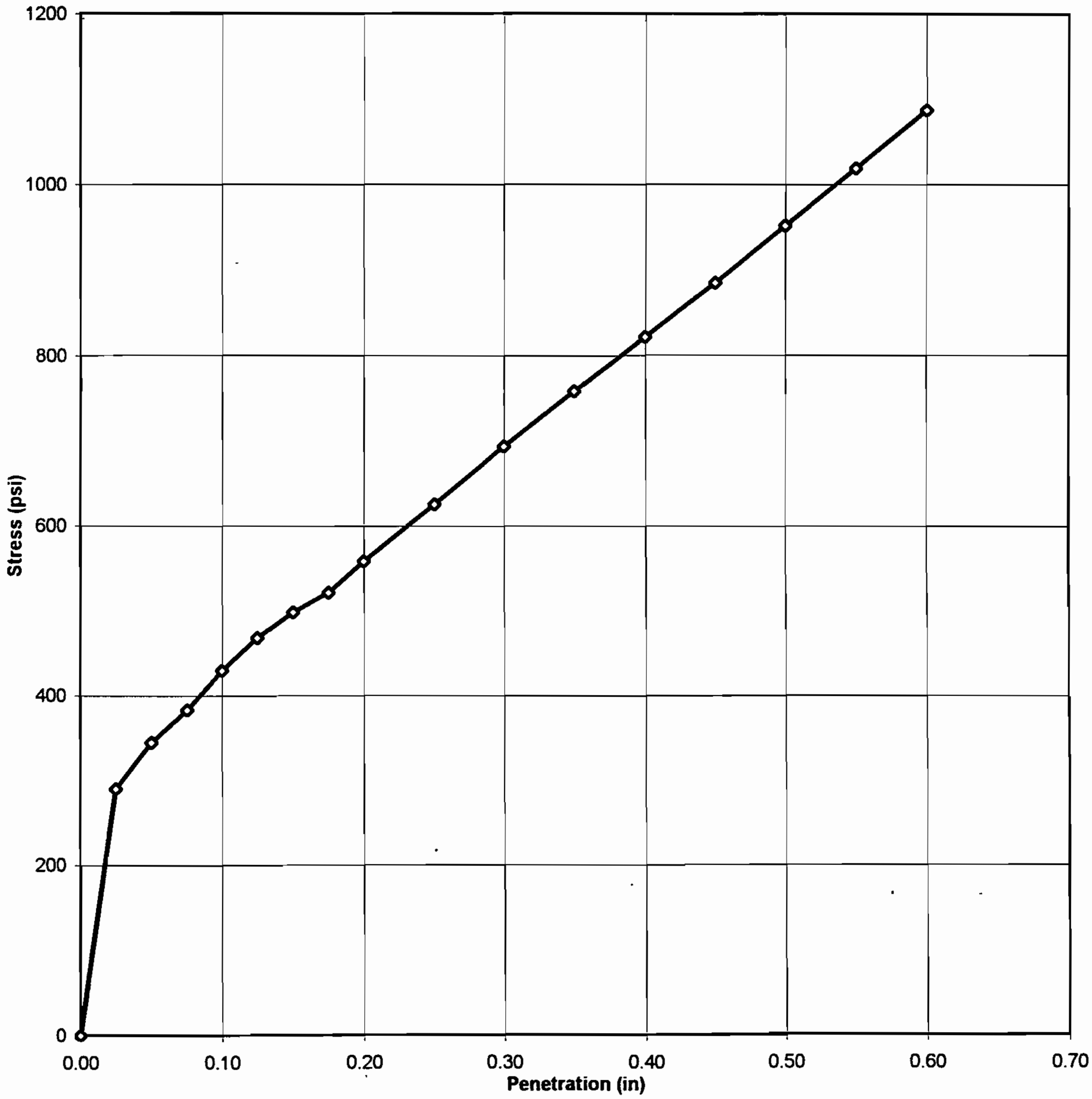
SINGLE POINT CBR TEST
ASTM D 1883-94(SOP-S27)

Client	TETRA TECH NUS	Boring No.	GFB-08-MB-03
Client Reference	GULFPORT NO567	Depth(ft.)	NA
Project No.	00248-03	Sample No.	PC ~~CK~~05-SD30
Lab ID	00248-03.004	Visual Description	BROWN CLAY,ROCK FRAGMENTS,& PORTLAND CEMENT ~~KILN DUST~~

Penetration Stress vs. Penetration

CBR VALUE (0.1")	43.00 %
CBR VALUE (0.2")	37.22 %



Tested By JP/GU *Date* 10/19/00 *Checked By* JMO *Date* 10/27/00

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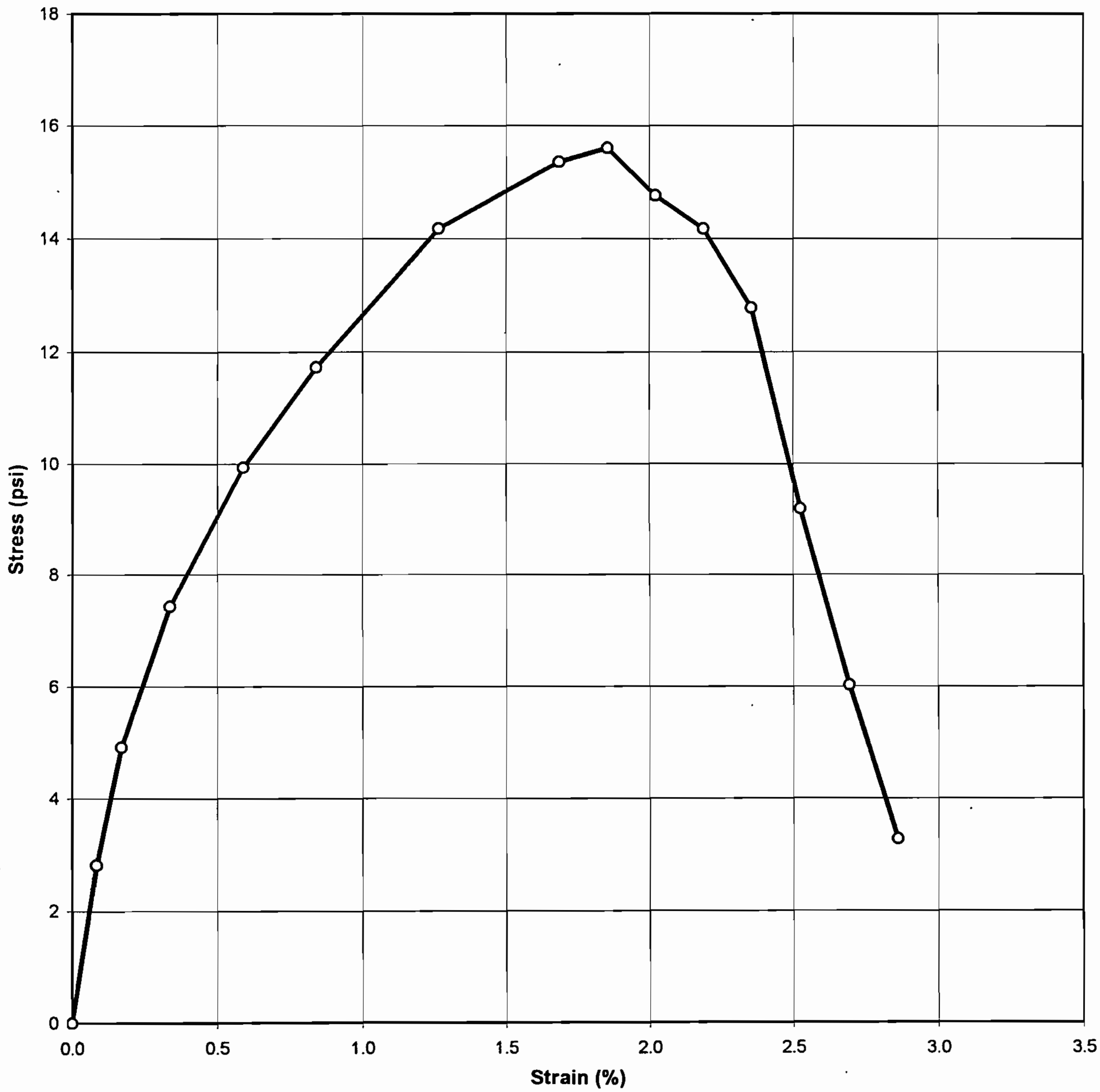
UNCONFINED COMPRESSIVE STRENGTH

ASTM D2166-91 (SOP S-30)

Client	TETRA TECH NUS	Boring No.	GFB-08-MB-03
Client Reference	GULFPORT N0567	Depth (ft.)	CURED 3 DAYS
Project No.	00248-03	Sample No.	PC ~~CK~~05-SD30
Lab ID	00248-03.004	Visual Description:	BROWN STABILIZED SLUDGE



Tested By GU Date 11/9/00 Checked By Jem Date 11-14-00

 DCN: CT-S30 DATE: 6-12-00 REVISION: 1 C \MSOFFICE\EXCEL\PrintQ\[E34 xls]Sheet1

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UNCONFINED COMPRESSIVE STRENGTH
ASTM D2166-91 (SOP S-30)

Client	TETRA TECH NUS	Boring No.	GFB-08-MB-03
Client Reference	GULFPORT N0567	Depth (ft.)	CURED 3 DAYS
Project No.	00248-03	Sample No.	PC ~~CK~~05-SD30
Lab ID	00248-03.004	Visual Description:	BROWN STABILIZED SLUDGE

INITIAL SAMPLE DIMENSIONS

Length 1(in)	5.948	Top Dia. (in)	3.041
Length 2(in)	5.929	Mid. Dia. (in)	3.011
Length 3(in)	5.937	Bot. Dia. (in)	2.973
Avg.Length(in	5.938	Area (in.^2)	7.108

WATER CONTENT

Tare No.	1724
Wt. Tare + WS.(gms)	702.50
Wt. Tare + DS.(gms)	591.90
Wt. of Tare(gms)	83.06
% Moisture	21.74

UNIT WEIGHT

Wt. Tube & WS.(gms.)	1315.4	Sample Volume(cc.)	691.6
Wt. Of Tube(gms.)	0.00	Unit Wet Wt.(gms/cc)	1.90
Wt. Of WS.(gms.)	1315.4	Unit Wet Wt.(pcf.)	118.68
Diameter (in.)	3.01	Moisture Content, %	21.74
Length (in.)	5.94	Unit Dry Wt.(pcf.)	97.49
Length (cm.)	15.08		

DEFORMATION (in)	*LOAD (lbs)*	*STRAIN (%)*	*STRESS (psi)*
0.000	0	0.00	0.00
0.005	20	0.08	2.81
0.010	35	0.17	4.92
0.020	53	0.34	7.43
0.035	71	0.59	9.93
0.050	84	0.84	11.72
0.075	102	1.26	14.17
0.100	111	1.68	15.35
0.110	113	1.85	15.60
0.120	107	2.02	14.75
0.130	103	2.19	14.17
0.140	93	2.36	12.78
0.150	67	2.53	9.19
0.160	44	2.69	6.02
0.170	24	2.86	3.28

Tested By GU Date 11/9/00 Checked By Jcm Date 11-14-00

 DCN: CT-S30 DATE: 6-12-00 REVISION: 1 *C:\MSOFFICE\EXCEL\PrintQ\[E34.xls]Sheet1*

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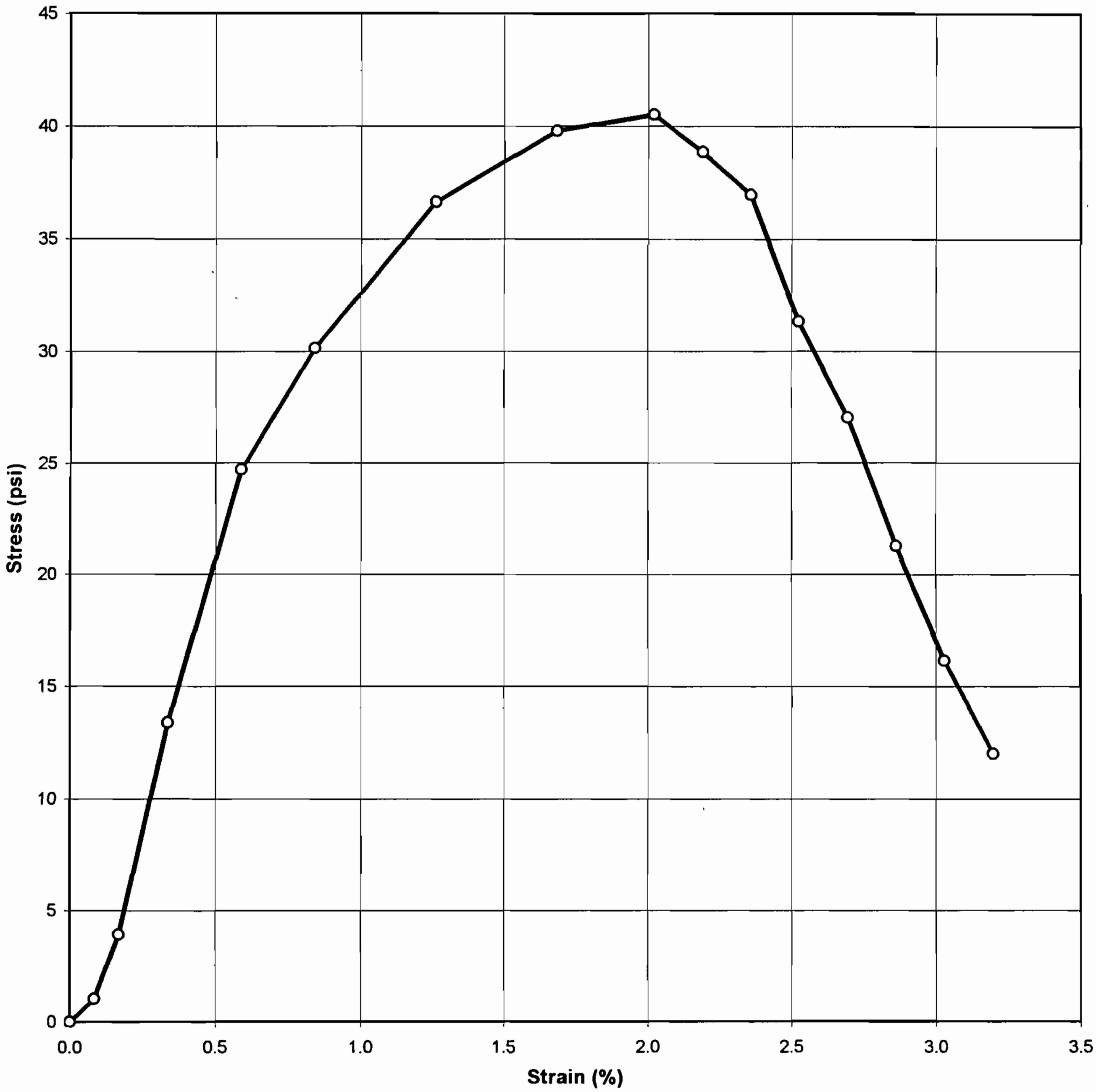
UNCONFINED COMPRESSIVE STRENGTH

ASTM D2166-91 (SOP S-30)

Client	TETRA TECH NUS	Boring No.	GFB-08-MB-03
Client Reference	GULFPORT NO567	Depth (ft.)	CURED 7 DAYS
Project No.	00248-03	Sample No.	RC ~~CK~~05-SD30
Lab ID	00248-03.004	Visual Description:	BROWN STABILIZED SLUDGE



Tested By GU/JP Date 10/27/00 Checked By DB Date 10/30/00

 DCN: CT-S30 DATE: 6-12-00 REVISION: 1 C:\MSOFFICE\EXCEL\PrintQ\[D65.xls]Sheet1

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UNCONFINED COMPRESSIVE STRENGTH
ASTM D2166-91 (SOP S-30)

Client	TETRA TECH NUS	Boring No.	GFB-08-MB-03
Client Reference	GULFPORT NO567	Depth (ft.)	CURED 7 DAYS
Project No.	00248-03	Sample No.	PC~~GK~~05-SD30
Lab ID	00248-03.004	Visual Description:	BROWN STABILIZED SLUDGE

INITIAL SAMPLE DIMENSIONS

Length 1(in)	5.925	Top Dia. (in)	2.957
Length 2(in)	5.949	Mid. Dia. (in)	2.948
Length 3(in)	5.942	Bot. Dia. (in)	2.952
Avg.Length(in	5.939	Area (in.^2)	6.846

WATER CONTENT

Tare No.	623
Wt. Tare + WS.(gms)	1408.50
Wt. Tare + DS.(gms)	1170.80
Wt. of Tare(gms)	83.78
% Moisture	21.87

UNIT WEIGHT

Wt. Tube & WS.(gms.)	1325.9	Sample Volume(cc.)	666.2
Wt. Of Tube(gms.)	0.00	Unit Wet Wt.(gms/cc)	1.99
Wt. Of WS.(gms.)	1325.9	Unit Wet Wt.(pcf.)	124.19
Diameter (in.)	2.95	Moisture Content, %	21.87
Length (in.)	5.94	Unit Dry Wt.(pcf.)	101.91
Length (cm.)	15.08		

DEFORMATION (in)	*LOAD (lbs)*	*STRAIN (%)*	*STRESS (psi)*
0.000	0	0.00	0.00
0.005	7	0.08	1.02
0.010	27	0.17	3.94
0.020	92	0.34	13.39
0.035	170	0.59	24.69
0.050	208	0.84	30.13
0.075	254	1.26	36.63
0.100	277	1.68	39.78
0.120	283	2.02	40.50
0.130	272	2.19	38.86
0.140	259	2.36	36.94
0.150	220	2.53	31.33
0.160	190	2.69	27.01
0.170	150	2.86	21.28
0.180	114	3.03	16.15
0.190	85	3.20	12.02

Tested By GU/JP Date 10/27/00 Checked By DB Date 10/30/00

DCN: CT-S30 DATE: 6-12-00 REVISION: 1 *C:\MSOFFICE\EXCEL\PrintQ\[D65.xls]Sheet1*

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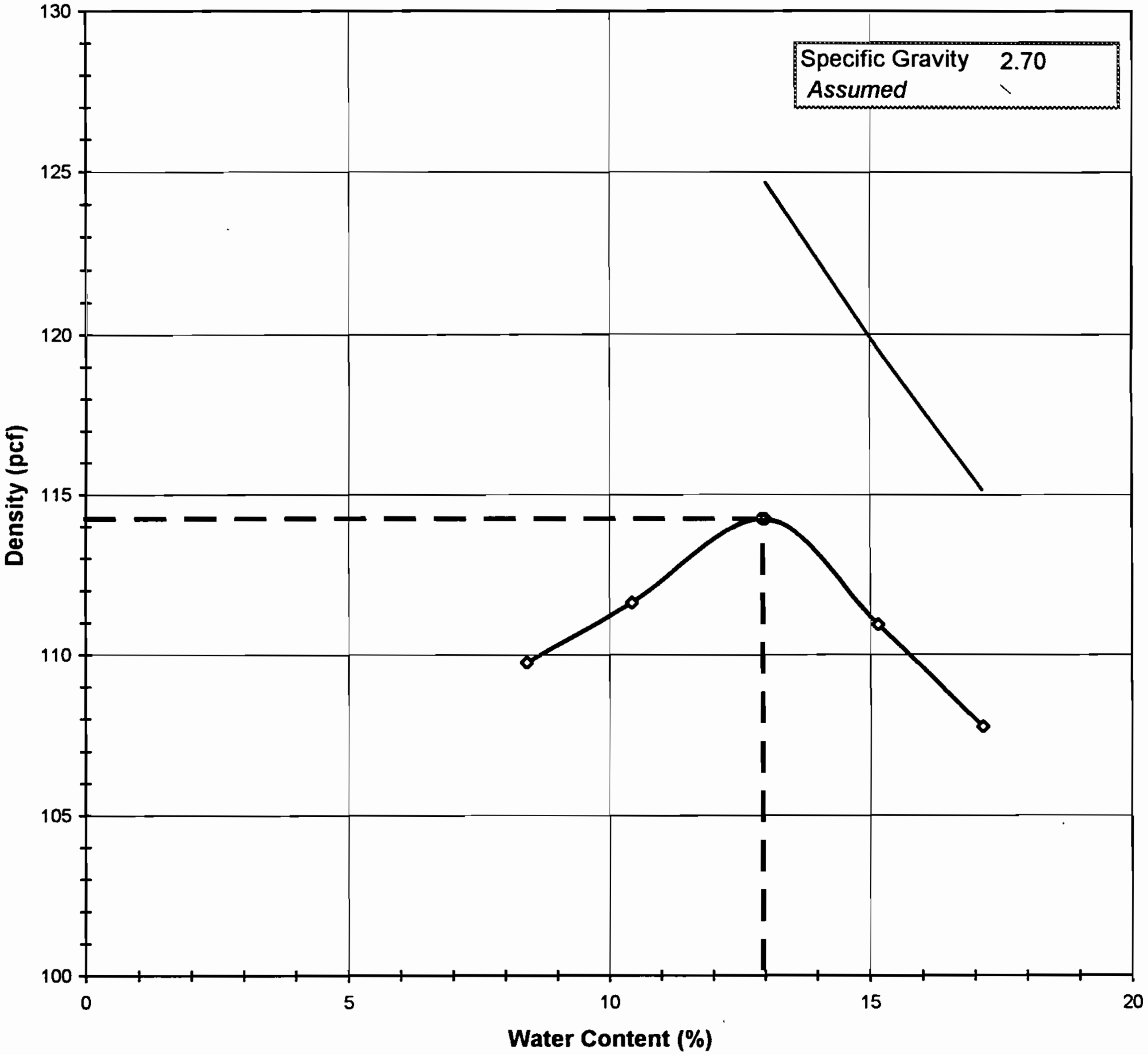
MOISTURE DENSITY RELATIONSHIP

ASTM D698-91 SOP-S12

Client	TETRA TECH NUS	Boring No.	GFB-08-MB-03
Client Reference	GULFPORT NO567	Depth (ft)	NA
Project No.	00248-03	Sample No.	CK10-SD15
Lab ID	00248-03.005	Test Method	**STANDARD**

Visual Description BROWN CLAY, ROCK FRAGMENTS, AND PORTLAND CEMENT ~~KILN DUST~~

Optimum Water Content	**13.0**
Maximum Dry Density	**114.2**



Tested By JP *Date* 10/25/00 *Checked By* JMO *Date* 10/27/00

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MOISTURE - DENSITY RELATIONSHIP

ASTM D698-91 SOP-S12

Client	TETRA TECH NUS	Boring No.	GFB-08-MB-03
Client Reference	GULFPORT NO567	Depth (ft)	NA
Project No.	00248-03	Sample No.	PC ~~CK~~10-SD15
Lab ID	00248-03.005		

Visual Description BROWN CLAY, ROCK FRAGMENTS, AND PORTLAND CEMENT ~~KILN DUST~~

Total Weight of the Sample (gm)	NA
As Received Water Content(%)	NA
Assumed Specific Gravity	2.70
Percent Retained on 3/4"	NA
Percent Retained on 3/8"	NA
Percent Retained on #4	NA
Oversize Material	Not included
Procedure Used	B

TestType	STANDARD
Rammer Weight (lbs)	5.5
Rammer Drop (in)	12
Rammer Type	MECHANICAL
Machine ID	G774
Mold ID	G606
Mold diameter	4"
Weight of the Mold	4234
Volume of the Mold(cc)	944

Mold / Specimen

Point No.	**1**	**2**	**3**	**4**	**5**
Wt. of Mold & WS (gm)	6034	6099	6187	6167	6144
Wt.of Mold (gm)	4234	4234	4234	4234	4234
Wt. of WS	1800	1865	1953	1933	1910
Mold Volume (cc)	944	944	944	944	944

Moisture Content / Density

Tare Number	595	1710	558	629	615
Wt. of Tare & WS (gm)	355.41	392.31	423.30	365.28	537.80
Wt. of Tare & DS (gm)	334.58	363.05	383.96	328.61	471.40
Wt. of Tare (gm)	86.93	82.67	81.49	86.67	84.44
Wt. of Water (gm)	20.83	29.26	39.34	36.67	66.40
Wt. of DS (gm)	247.65	280.38	302.47	241.94	386.96

Wet Density (gm/cc)	1.91	1.98	2.07	2.05	2.02
Wet Density (pcf)	119.0	123.3	129.1	127.8	126.3
Moisture Content (%)	**8.4**	**10.4**	**13.0**	**15.2**	**17.2**
Dry Density (pcf)	**109.8**	**111.6**	**114.2**	**111.0**	**107.8**
Pocket Penetrometer (tsf) TOP	0.0	0.0	0.0	1.75	0.5

Zero Air Voids

Moisture Content (%)	13.0	15.2	17.2
Dry Unit Weight (pcf)	124.7	119.6	115.1

Tested By JP *Date* 10/25/00 *Checked By* JMC *Date* 10/27/00

 DCN:CT-S12 DATE: 6-25-98 REVISION 3 *C:\MSOFFICE\EXCEL\PrintQ\[D43.xls]Sheet1*

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DCN: CT-S27
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SINGLE POINT CBR TEST

ASTM D 1883-94(SOP-S27)

Client	TETRA TECH NUS	Boring No.	GFB-08-MB-03
Client Reference	GULFPORT NO567	Depth(ft.)	NA
Project No.	00248-03	Sample No.	PC ~~CK~~10-SD15
Lab ID	00248-03.005	Visual Description	BROWN CLAY,ROCK FRAGMENTS,& PORTLAND CEMENT ~~KILN DUST~~

		Density Measurement	Before Soaking	After Soaking	Top 1"
Test Type	**STANDARD**	Wt. Mold & WS (gm.)	11428	11434	
Molding Method	C	Wt. WS (gm.)	4251	4257	
Mold ID	C	Sample Volume (cc)	2124	2119	
Wt. of Mold (gm.)	7177	Wet Density (gm./cc)	2.00	2.01	
Mold Volume (cc)	2124	Wet Density (pcf)	124.9	125.3	
Surcharge (lbs.)	**20**	Tare No.	1710	516	1301
Piston Area (in^2)	3	Wt. of T+WS (gm.)	805.9	890.2	557.4
Sample Height	4.58	Wt. of T+DS (gm.)	683.5	767.9	484.6
		Wt of Tare (gm.)	82.7	98.38	101.47
Sample Conditions	Soaked	Moisture Content	20.4%	18.3%	19.0%
Blows per Layer	**56**				
		Dry Density (pcf)	**103.8**	**106.0**	
		Dry Density (gm./cc)	**1.66**	**1.70**	

Placed @ as received water content

Piston isplacement (in.)	Load (lbs.)	Penetration Stress (psi.)
0	0	0.0
0.025	1655	551.7
0.050	2445	815.0
0.075	3010	1003.3
0.100	3500	1166.7
0.125	3945	1315.0
0.150	4305	1435.0
0.175	4665	1555.0
0.200	5005	1668.3
0.250	5585	1861.7
0.300	6165	2055.0
0.350	6705	2235.0
0.400	7210	2403.3
0.450	7720	2573.3
0.500	8210	2736.7
0.550	8710	2903.3
0.600	9190	3063.3

Swell Measurement

Elapsed Time (hrs)	Dial Gauge (Div)	Percent Swell
0	500	0.00%
0.1	493	-0.15%
0.3	491	-0.20%
0.4	490	-0.22%
1.4	488	-0.26%
19.7	489	-0.24%
96.2	489	-0.24%

1Division 0.001 in.

Tested By *JP/GU* *Date* *10/19/00* *Checked By* JMO *Date* 10/27/00

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DCN: CT-S27
DATE: 12/16/96
REVISION: 1

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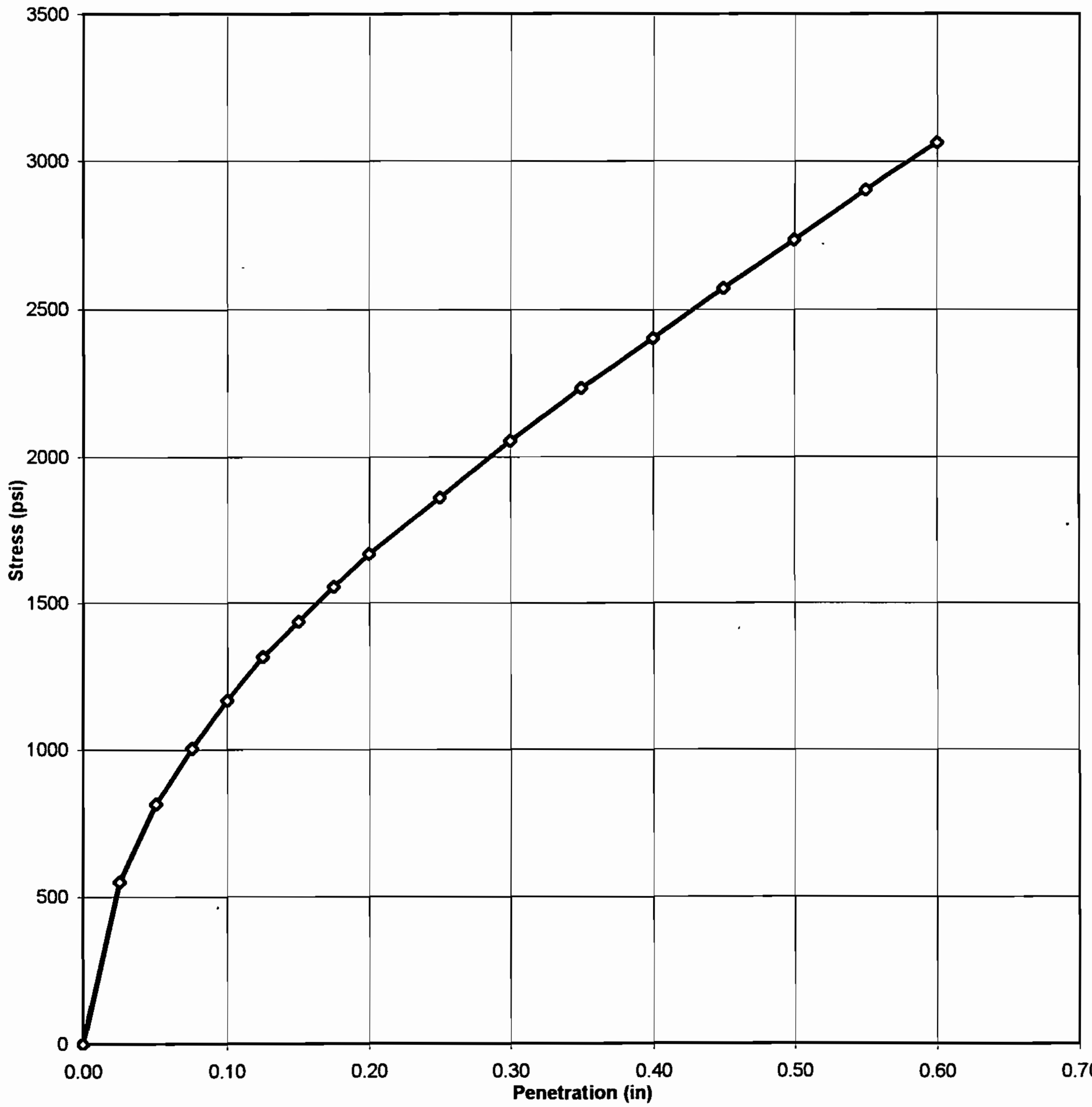
SINGLE POINT CBR TEST
ASTM D 1883-94(SOP-S27)

Client	TETRA TECH NUS	Boring No.	GFB-08-MB-03
Client Reference	GULFPORT NO567	Depth(ft.)	NA
Project No.	00248-03	Sample No.	PC ~~CK~~10-SD15
Lab ID	00248-03.005	Visual Description	BROWN CLAY,ROCK FRAGMENTS,& PORTLAND CEMENT ~~KILN DUST~~

Penetration Stress vs. Penetration

CBR VALUE (0.1")	**116.67 %**
CBR VALUE (0.2")	**111.22 %**



Tested By *JP/GU* *Date* *10/19/00* *Checked By* JMO *Date* 10/27/00

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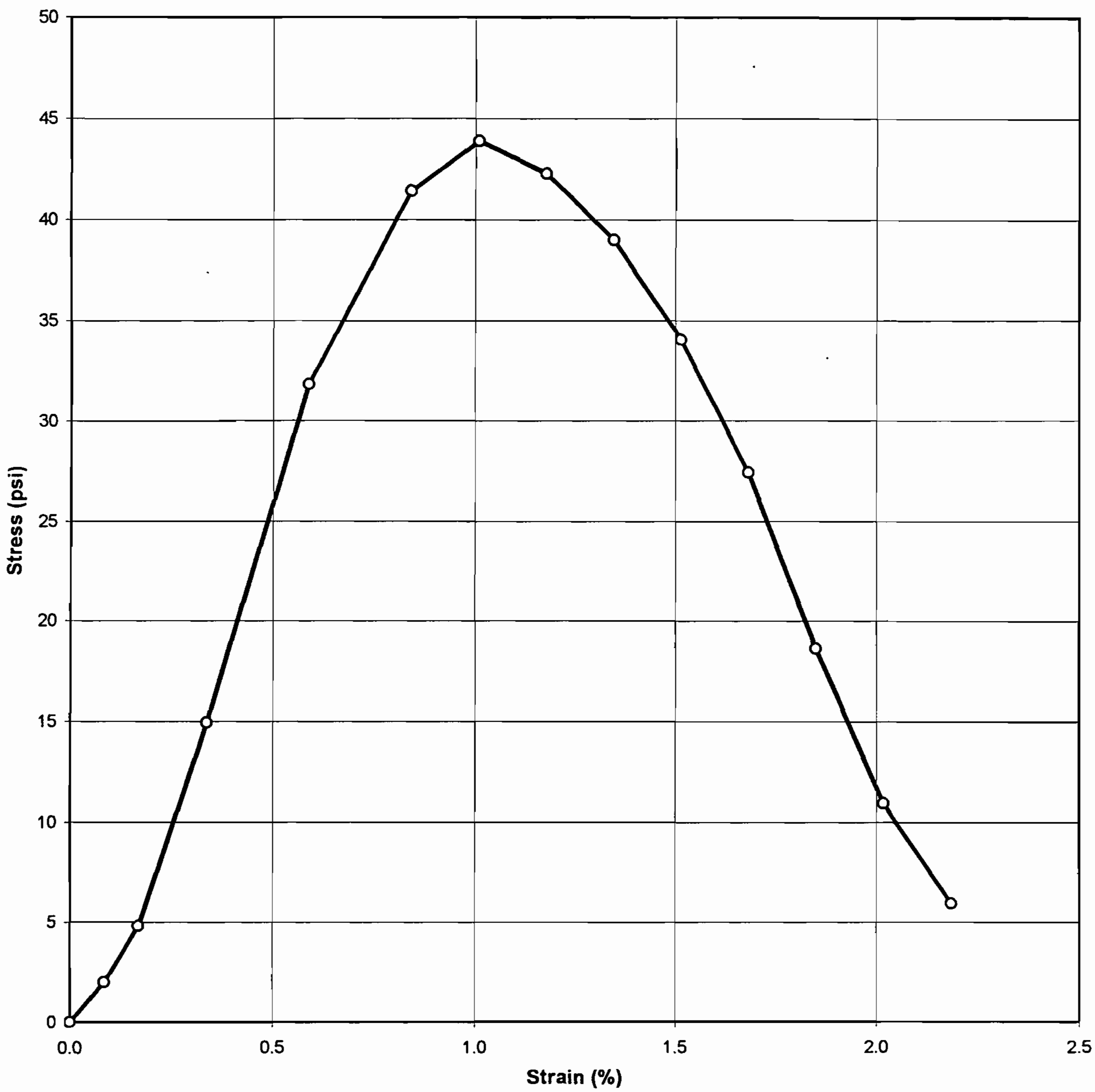
UNCONFINED COMPRESSIVE STRENGTH
ASTM D2166-91 (SOP S-30)

Client	TETRA TECH NUS	Boring No.	GFB-08-MB-03
Client Reference	GULFPORT N0567	Depth (ft.)	CURED 3 DAYS
Project No.	00248-03	Sample No.	PC ~~CK~~10-SD15
Lab ID	00248-03.005	Visual Description:	BROWN STABILIZED SLUDGE



Tested By GU Date 11/9/00 Checked By Jcm Date 11-14-00

 DCN: CT-S30 DATE: 6-12-00 REVISION: 1 C:\MSOFFICE\EXCEL\PrintQ\[E35 xls]Sheet1

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UNCONFINED COMPRESSIVE STRENGTH
ASTM D2166-91 (SOP S-30)

Client	TETRA TECH NUS	Boring No.	GFB-08-MB-03
Client Reference	GULFPORT N0567	Depth (ft.)	CURED 3 DAYS
Project No.	00248-03	Sample No.	PC ~~GK~~10-SD15
Lab ID	00248-03.005	Visual Description:	BROWN STABILIZED SLUDGE

INITIAL SAMPLE DIMENSIONS

Length 1(in)	5.943	Top Dia. (in)	3.011
Length 2(in)	5.947	Mid. Dia. (in)	3.005
Length 3(in)	5.945	Bot. Dia. (in)	2.979
Avg.Length(in	5.945	Area (in.^2)	7.061

WATER CONTENT

Tare No.	607
Wt. Tare + WS.(gms)	724.10
Wt. Tare + DS.(gms)	624.20
Wt. of Tare(gms)	82.95
% Moisture	18.46

UNIT WEIGHT

Wt. Tube & WS.(gms.)	1247	Sample Volume(cc.)	687.9
Wt. Of Tube(gms.)	0.00	Unit Wet Wt.(gms/cc)	1.81
Wt. Of WS.(gms.)	1247	Unit Wet Wt.(pcf.)	113.12
Diameter (in.)	3.00	Moisture Content, %	18.46
Length (in.)	5.95	Unit Dry Wt.(pcf.)	95.50
Length (cm.)	15.10		

DEFORMATION (in)	*LOAD (lbs)*	*STRAIN (%)*	*STRESS (psi)*
0.000	0	0.00	0.00
0.005	14	0.08	1.98
0.010	34	0.17	4.81
0.020	106	0.34	14.96
0.035	226	0.59	31.82
0.050	295	0.84	41.43
0.060	313	1.01	43.88
0.070	302	1.18	42.27
0.080	279	1.35	38.98
0.090	244	1.51	34.03
0.100	197	1.68	27.43
0.110	134	1.85	18.63
0.120	79	2.02	10.96
0.130	43	2.19	5.96

Tested By GU Date 11/9/00 Checked By Jm Date 11-14-00

DCN: CT-S30 DATE: 6-12-00 REVISION: 1
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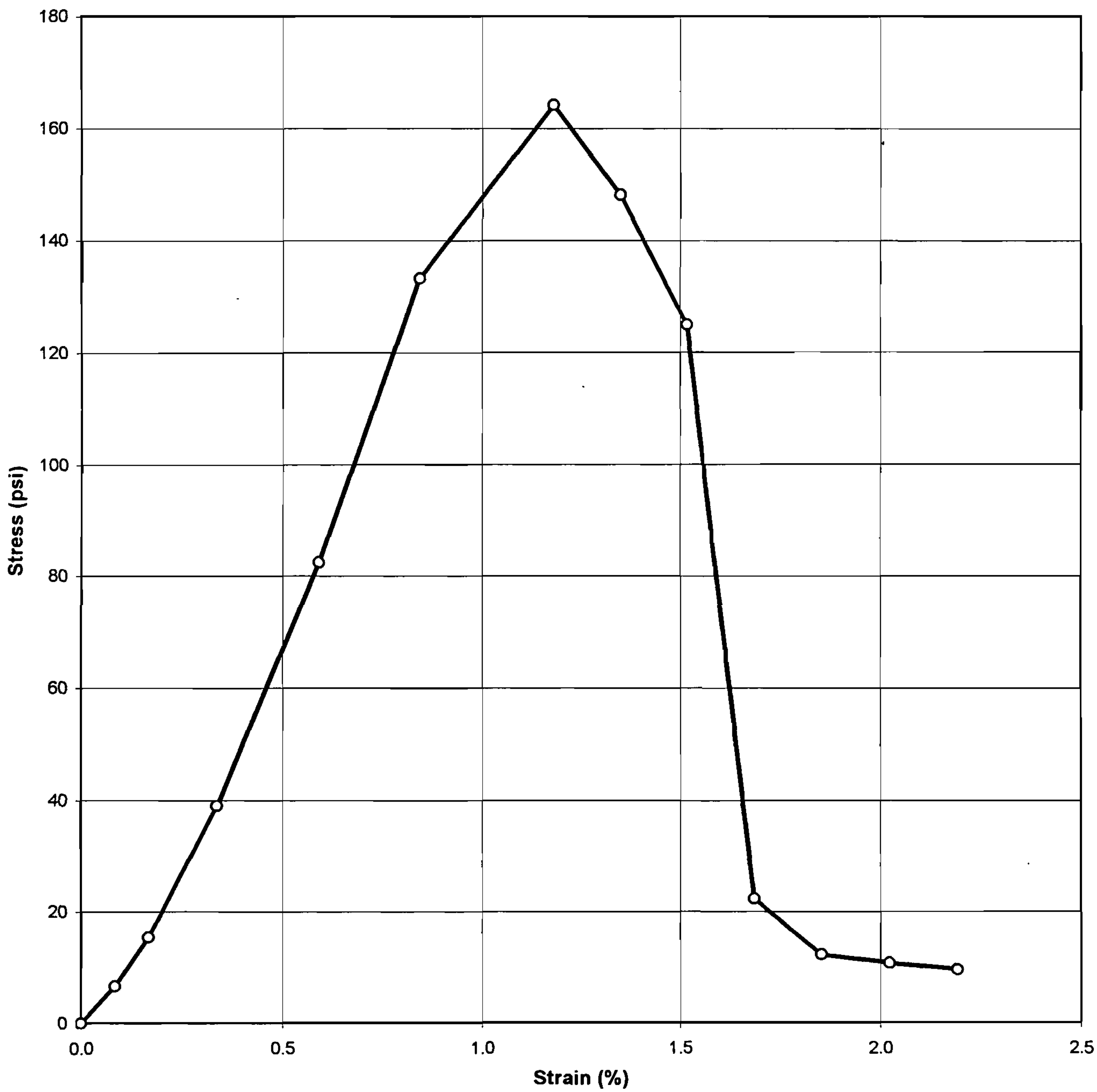
UNCONFINED COMPRESSIVE STRENGTH
ASTM D2166-91 (SOP S-30)

Client	TETRA TECH NUS	Boring No.	GFB-08-MB-03
Client Reference	GULFPORT NO567	Depth (ft.)	CURED 7 DAYS
Project No.	00248-03	Sample No.	PC ~~CK~~10-SD15
Lab ID	00248-03.005	Visual Description:	BROWN STABILIZED SLUDGE



Tested By GU/JP Date 10/27/00 Checked By DB Date 10/30/00

 DCN: CT-S30 DATE: 6-12-00 REVISION: 1 C:\MSOFFICE\EXCEL\PrintQ\[D66.xls]Sheet1

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UNCONFINED COMPRESSIVE STRENGTH

ASTM D2166-91 (SOP S-30)

Client	TETRA TECH NUS	Boring No.	GFB-08-MB-03
Client Reference	GULFPORT NO567	Depth (ft.)	CURED 7 DAYS
Project No.	00248-03	Sample No.	PCGK10-SD15
Lab ID	00248-03.005	Visual Description:	BROWN STABILIZED SLUDGE

INITIAL SAMPLE DIMENSIONS

Length 1(in)	5.908	Top Dia. (in)	2.985
Length 2(in)	5.928	Mid. Dia. (in)	3.017
Length 3(in)	5.958	Bot. Dia. (in)	3.066
Avg.Length(in	5.931	Area (in.^2)	7.176

WATER CONTENT

Tare No.	568
Wt. Tare + WS.(gms)	1458.60
Wt. Tare + DS.(gms)	1256.10
Wt. of Tare(gms)	84.63
% Moisture	17.29

UNIT WEIGHT

Wt. Tube & WS.(gms.)	1377	Sample Volume(cc.)	697.5
Wt. Of Tube(gms.)	0.00	Unit Wet Wt.(gms/cc)	1.97
Wt. Of WS.(gms.)	1377	Unit Wet Wt.(pcf.)	123.20
Diameter (in.)	3.02	Moisture Content, %	17.29
Length (in.)	5.93	Unit Dry Wt.(pcf.)	105.04
Length (cm.)	15.07		

DEFORMATION (in)	*LOAD (lbs)*	*STRAIN (%)*	*STRESS (psi)*
0.000	0	0.00	0.00
0.005	47	0.08	6.54
0.010	111	0.17	15.44
0.020	281	0.34	39.03
0.035	595	0.59	82.43
0.050	964	0.84	133.21
0.070	1192	1.18	164.15
0.080	1077	1.35	148.06
0.090	910	1.52	124.89
0.100	163	1.69	22.33
0.110	89	1.85	12.17
0.120	78	2.02	10.65
0.130	70	2.19	9.54

Tested By GU/JP Date 10/27/00 Checked By DB Date 10/30/00

DCN: CT-S30 DATE: 6-12-00 REVISION: 1
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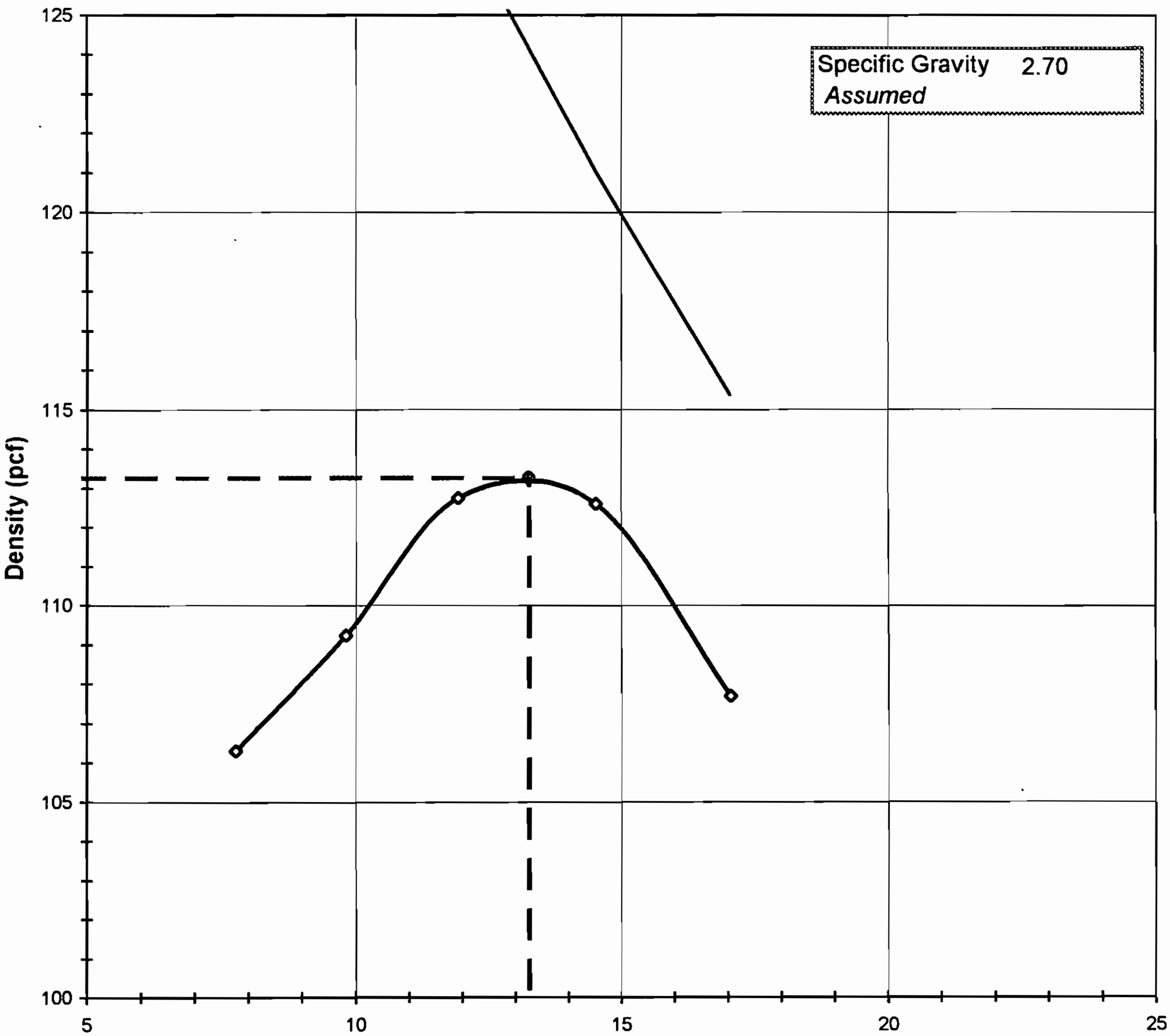
MOISTURE DENSITY RELATIONSHIP

ASTM D698-91 SOP-S12

Client	TETRA TECH NUS	Boring No.	GFB-08-MB-03
Client Reference	GULFPORT NO567	Depth (ft)	NA
Project No.	00248-03	Sample No.	PC ~~CK~~10-SD30
Lab ID	00248-03.006	Test Method	**STANDARD**

Visual Description BROWN CLAY, ROCK FRAGMENTS, AND PORTLAND CEMENT ~~KILN DUST~~

Optimum Water Content **13.3**
Maximum Dry Density **113.3**



Tested By	*JP*	*Date*	*10/23/00*	*Checked By*	*Jcm*	*Date*	*10-24-00*

 DCN:CT-S12 DATE: 6-25-98 REVISION 3 *C:\MSOFFICE\EXCEL\PrintQ\[D3.xls]Sheet1*

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MOISTURE - DENSITY RELATIONSHIP

ASTM D698-91 SOP-S12

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Client	TETRA TECH NUS	Boring No.	GFB-08-MB-03
Client Reference	GULFPORT NO567	Depth (ft)	NA
Project No.	00248-03	Sample No.	PC ~~GK~~10-SD30
Lab ID	00248-03.006		

Visual Description BROWN CLAY, ROCK FRAGMENTS, AND PORTLAND CEMENT ~~KILN DUST~~

Total Weight of the Sample (gm)	NA
As Received Water Content(%)	NA
Assumed Specific Gravity	2.70
Percent Retained on 3/4"	NA
Percent Retained on 3/8"	NA
Percent Retained on #4	NA
Oversize Material	Not included
Procedure Used	B

TestType	STANDARD
Rammer Weight (lbs)	5.5
Rammer Drop (in)	12
Rammer Type	Manual
Machine ID	NA
Mold ID	G606
Mold diameter	4"
Weight of the Mold	4234
Volume of the Mold(cc)	944

Mold / Specimen

Point No.	1	2	3	4	5
Wt. of Mold & WS (gm)	5967	6049	6143	6185	6141
Wt.of Mold (gm)	4234	4234	4234	4234	4234
Wt. of WS	1733	1815	1909	1951	1907
Mold Volume (cc)	944	944	944	944	944

Moisture Content / Density

Tare Number	1128	1704	558	629	595
Wt. of Tare & WS (gm)	334.09	381.40	341.01	349.37	572.90
Wt. of Tare & DS (gm)	316.09	354.84	313.36	316.05	502.10
Wt. of Tare (gm)	84.20	84.39	81.49	86.64	86.90
Wt. of Water (gm)	18.00	26.56	27.65	33.32	70.80
Wt. of DS (gm)	231.89	270.45	231.87	229.41	415.20

Wet Density (gm/cc)	1.84	1.92	2.02	2.07	2.02
Wet Density (pcf)	114.6	120.0	126.2	129.0	126.1
Moisture Content (%)	**7.8**	**9.8**	**11.9**	**14.5**	**17.1**
Dry Density (pcf)	**106.3**	**109.2**	**112.7**	**112.6**	**107.7**
Pocket Penetrometer (TSF) TOP	0.00	0.00	0.00	3.00	0.75

Zero Air Voids

Moisture Content (%)	11.9	14.5	17.1
Dry Unit Weight (pcf)	127.4	121.0	115.4

Tested By JP *Date* 10/23/00 *Checked By* Jcm *Date* 10.24.00

 DCN:CT-S12 DATE: 6-25-98 REVISION 3 *C:\MSOFFICE\EXCEL\PrintQ\[D3.xls]Sheet1*

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DCN: CT-S27
DATE: 12/16/96
REVISION: 1

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SINGLE POINT CBR TEST

ASTM D 1883-94(SOP-S27)

Client	TETRA TECH NUS	Boring No.	GFB-08-MB-03
Client Reference	GULFPORT NO567	Depth(ft.)	NA
Project No.	00248-03	Sample No.	PC ~~CK~~10-SD30
Lab ID	00248-03.006	Visual Description	BROWN CLAY,ROCK FRAGMENTS,& PORTLAND CEMENT ~~KILN DUST~~

		Density Measurement	**Before Soaking**	**After Soaking**	**Top 1"**
Test Type	**STANDARD**	Wt. Mold & WS (gm.)	11285	11280	
Molding Method	C	Wt. WS (gm.)	4196	4191	
Mold ID	F	Sample Volume (cc)	2124	2119	
Wt. of Mold (gm.)	7089	Wet Density (gm./cc)	1.98	1.98	
Mold Volume (cc)	2124	Wet Density (pcf)	123.3	123.7	
Surcharge (lbs.)	**20**	Tare No.	1741	2445	1633
Piston Area (in^2)	3	Wt. of T+WS (gm.)	752.1	1651.7	944.2
Sample Height	4.58	Wt. of T+DS (gm.)	632.1	1406.7	806.7
		Wt of Tare (gm.)	83.48	94.02	95.39
Sample Conditions	Soaked	Moisture Content	21.9%	18.7%	19.3%
Blows per Layer	**56**				
		Dry Density (pcf)	**101.1**	**104.3**	
		Dry Density (gm./cc)	**1.62**	**1.67**	

Placed @ as received water content

Piston isplacement (in.)	**Load (lbs.)**	**Penetration Stress (psi.)**
0	0	0.0
0.025	2505	835.0
0.050	3490	1163.3
0.075	4130	1376.7
0.100	4670	1556.7
0.125	5115	1705.0
0.150	5485	1828.3
0.175	5860	1953.3
0.200	6210	2070.0
0.250	6795	2265.0
0.300	7400	2466.7
0.350	7945	2648.3
0.400	8525	2841.7
0.450	9070	3023.3
0.500	9610	3203.3
0.550	10220	3406.7
0.600	10806	3602.0

Swell Measurement

Elapsed Time (hrs)	Dial Gauge (Div)	Percent Swell
0	500	0.00%
0.1	484	-0.35%
0.3	478	-0.48%
0.4	474	-0.57%
1.4	462	-0.83%
19.7	461	-0.85%
96.2	461	-0.85%

1Division 0.001 in.

Tested By *JP/GU* *Date* *10/19/00* *Checked By* JMO *Date* 10/27/00

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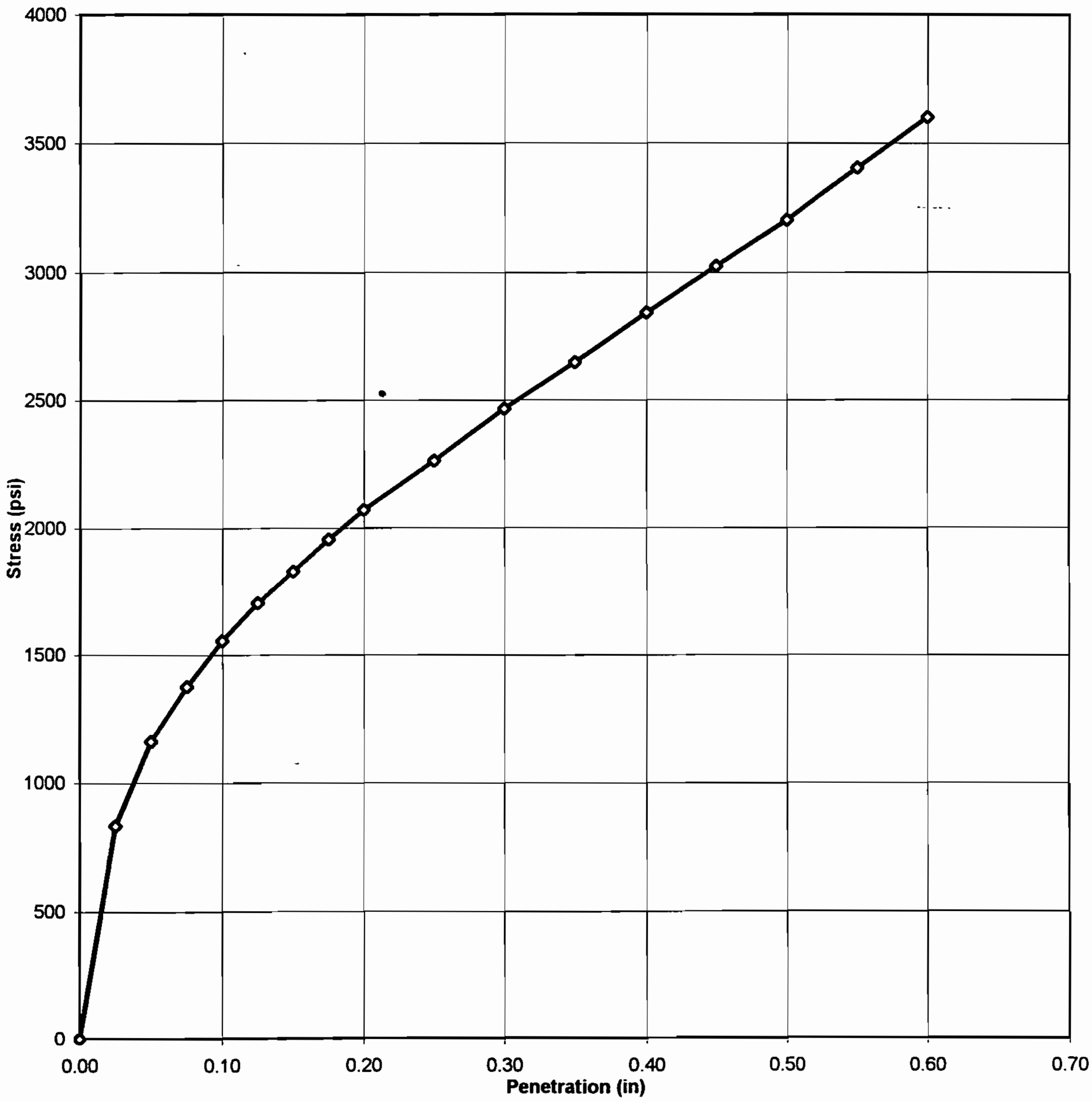
SINGLE POINT CBR TEST
ASTM D 1883-94(SOP-S27)

Client	TETRA TECH NUS	Boring No.	GFB-08-MB-03
Client Reference	GULFPORT NO567	Depth(ft.)	NA
Project No.	00248-03	Sample No.	PC ~~CK~~10-SD30
Lab ID	00248-03.006	Visual Description	BROWN CLAY,ROCK FRAGMENTS,& PORTLAND CEMENT ~~KILN DUST~~

Penetration Stress vs. Penetration

CBR VALUE (0.1")	**155.67 %**
CBR VALUE (0.2")	**138.00 %**



Tested By *JP/GU* *Date* *10/19/00* *Checked By* JMC *Date* 10/27/00

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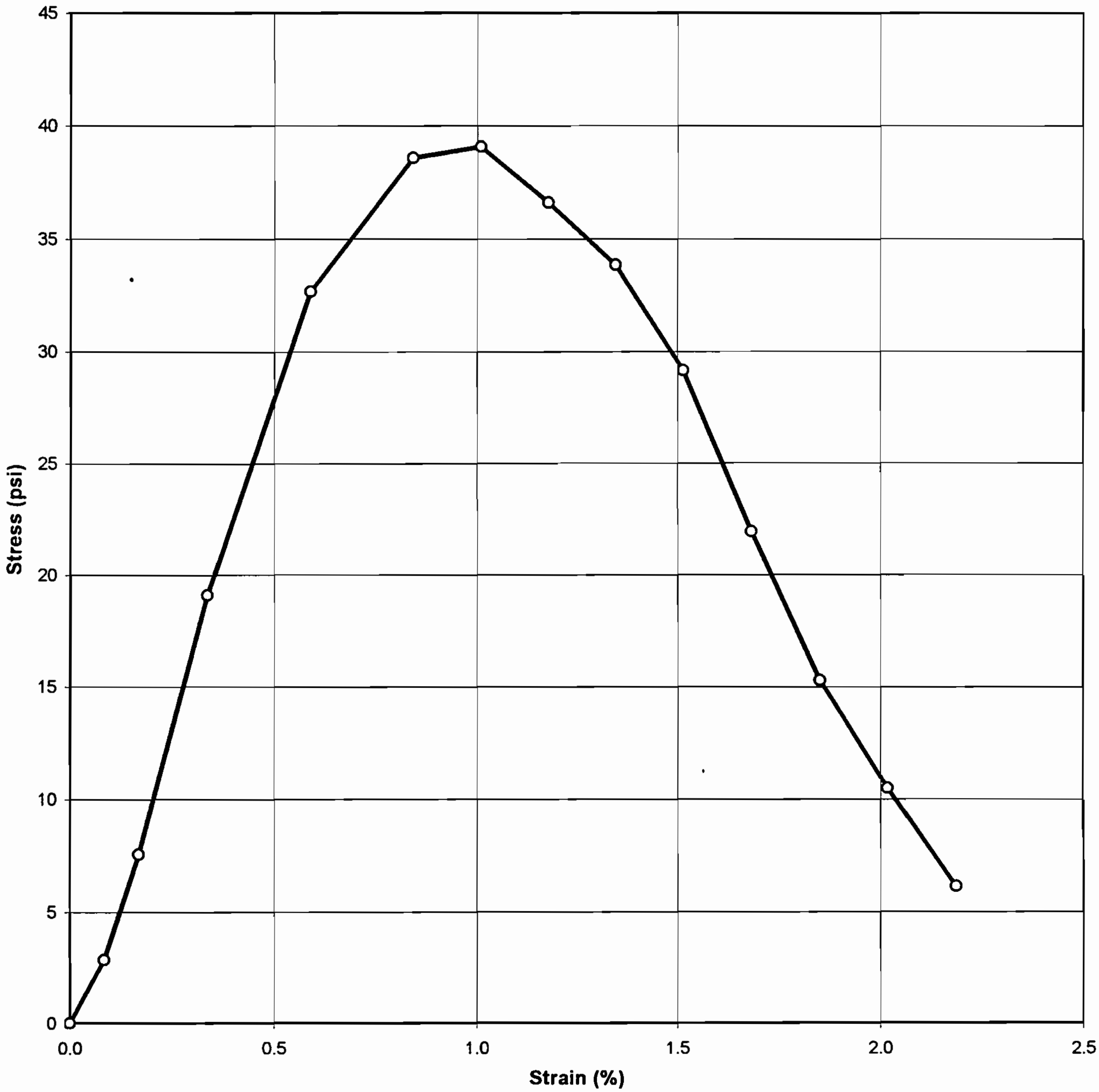
UNCONFINED COMPRESSIVE STRENGTH
ASTM D2166-91 (SOP S-30)

Client	TETRA TECH NUS	Boring No.	GFB-08-MB-03
Client Reference	GULFPORT N0567	Depth (ft.)	CURED 3 DAYS
Project No.	00248-03	Sample No.	PC ~~CK~~10-SD30
Lab ID	00248-03.006	Visual Description:	BROWN STABILIZED SLUDGE



Tested By GU Date 11/9/00 Checked By Jcm Date 11-14-00

 DCN: CT-S30 DATE: 6-12-00 REVISION: 1 C:\MSOFFICE\EXCEL\PrintQ\[e36 xls]Sheet1

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UNCONFINED COMPRESSIVE STRENGTH
ASTM D2166-91 (SOP S-30)

Client	TETRA TECH NUS	Boring No.	GFB-08-MB-03
Client Reference	GULFPORT N0567	Depth (ft.)	CURED 3 DAYS
Project No.	00248-03	Sample No.	PC ~~CK~~10-SD30
Lab ID	00248-03.006	Visual Description:	BROWN STABILIZED SLUDGE

INITIAL SAMPLE DIMENSIONS

Length 1(in)	5.952	Top Dia. (in)	2.994
Length 2(in)	5.938	Mid. Dia. (in)	2.989
Length 3(in)	5.945	Bot. Dia. (in)	2.969
Avg.Length(in	5.945	Area (in.^2)	6.993

WATER CONTENT

Tare No.	630
Wt. Tare + WS.(gms)	852.60
Wt. Tare + DS.(gms)	724.50
Wt. of Tare(gms)	82.60
% Moisture	19.96

UNIT WEIGHT

Wt. Tube & WS.(gms.)	1287.5	Sample Volume(cc.)	681.3
Wt. Of Tube(gms.)	0.00	Unit Wet Wt.(gms/cc)	1.89
Wt. Of WS.(gms.)	1287.5	Unit Wet Wt.(pcf.)	117.92
Diameter (in.)	2.98	Moisture Content, %	19.96
Length (in.)	5.95	Unit Dry Wt.(pcf.)	98.30
Length (cm.)	15.10		

DEFORMATION (in)	*LOAD (lbs)*	*STRAIN (%)*	*STRESS (psi)*
0.000	0	0.00	0.00
0.005	20	0.08	2.86
0.010	53	0.17	7.57
0.020	134	0.34	19.10
0.035	230	0.59	32.69
0.050	272	0.84	38.57
0.060	276	1.01	39.07
0.070	259	1.18	36.60
0.080	240	1.35	33.86
0.090	207	1.51	29.15
0.100	156	1.68	21.93
0.110	109	1.85	15.30
0.120	75	2.02	10.51
0.130	44	2.19	6.15

Tested By GU Date 11/9/00 Checked By Jcm Date 11-14-00

DCN: CT-S30 DATE: 6-12-00 REVISION: 1 C:\MSOFFICE\EXCEL\PrintQ\[e36 xls]Sheet1

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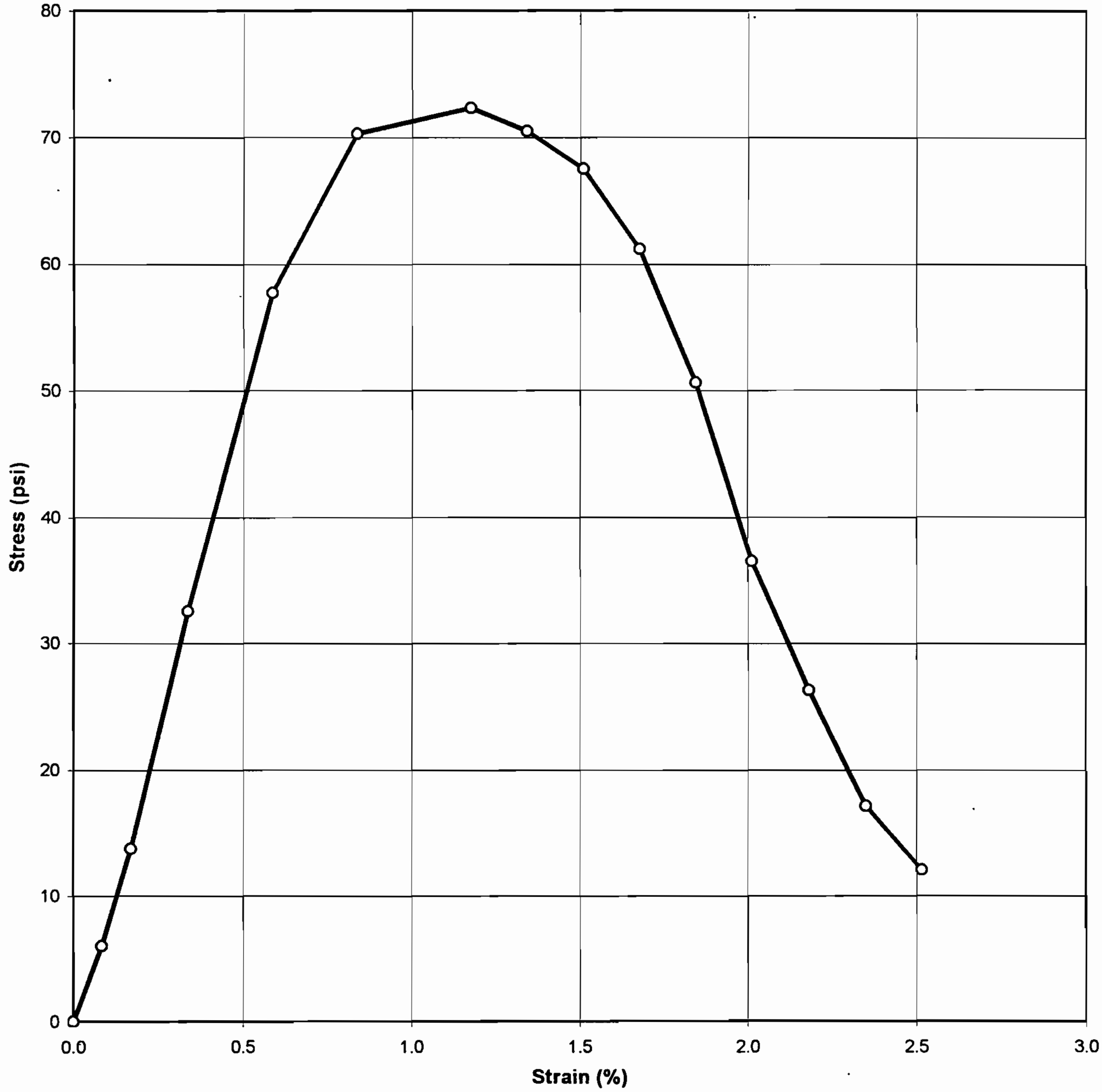
UNCONFINED COMPRESSIVE STRENGTH
ASTM D2166-91 (SOP S-30)

Client	TETRA TECH NUS	Boring No.	GFB-08-MB-03
Client Reference	GULFPORT NO567	Depth (ft.)	CURED 7 DAYS
Project No.	00248-03	Sample No.	PC ~~GK~~10-SD30
Lab ID	00248-03.006	Visual Description:	BROWN STABILIZED SLUDGE



Tested By GU/JP Date 10/27/00 Checked By DB Date 10/30/00

DCN: CT-S30 DATE: 6-12-00 REVISION: 1
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geotechnics

UNCONFINED COMPRESSIVE STRENGTH
ASTM D2166-91 (SOP S-30)

Client	TETRA TECH NUS	Boring No.	GFB-08-MB-03
Client Reference	GULFPORT NO567	Depth (ft.)	CURED 7 DAYS
Project No.	00248-03	Sample No.	PC ~~CK~~10-SD30
Lab ID	00248-03.006	Visual Description:	BROWN STABILIZED SLUDGE

INITIAL SAMPLE DIMENSIONS

Length 1(in)	5.957	Top Dia. (in)	2.985
Length 2(in)	5.964	Mid. Dia. (in)	2.978
Length 3(in)	5.961	Bot. Dia. (in)	2.964
Avg.Length(in	5.961	Area (in.^2)	6.954

WATER CONTENT

Tare No.	613
Wt. Tare + WS.(gms)	1434.40
Wt. Tare + DS.(gms)	1218.70
Wt. of Tare(gms)	85.07
% Moisture	19.03

UNIT WEIGHT

Wt. Tube & WS.(gms.)	1354.3	Sample Volume(cc.)	679.3
Wt. Of Tube(gms.)	0.00	Unit Wet Wt.(gms/cc)	1.99
Wt. Of WS.(gms.)	1354.3	Unit Wet Wt.(pcf.)	124.41
Diameter (in.)	2.98	Moisture Content, %	19.03
Length (in.)	5.96	Unit Dry Wt.(pcf.)	104.52
Length (cm.)	15.14		

DEFORMATION (in)	*LOAD (lbs)*	*STRAIN (%)*	*STRESS (psi)*
0.000	0	0.00	0.00
0.005	42	0.08	6.03
0.010	96	0.17	13.78
0.020	227	0.34	32.53
0.035	404	0.59	57.75
0.050	493	0.84	70.30
0.070	509	1.17	72.33
0.080	497	1.34	70.51
0.090	477	1.51	67.55
0.100	433	1.68	61.22
0.110	359	1.85	50.67
0.120	259	2.01	36.49
0.130	187	2.18	26.30
0.140	122	2.35	17.13
0.150	86	2.52	12.06

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